Table A-3
Depth to Water and Aquifer Bottom

Cluster	Well Number	Depth to Water (feet)	Depth to Aquifer Bottom (feet)
1A	01902786	225 *	1349
1B	01900018	345	544
1C	01900013	279	822
	01900012	259	778
1E	01903097	258	916
	01901681	316	952
2A	01902030	174	1000
	01902461	173	999
2B	01902018	106 *	1220
	01902017	106 *	1220
	01900418	137	1323
	01900419	141	1235
	01900356	139 *	1018
2C	01902019	139	1213
	01900420	103 *	1268
	01900417	96 *	1319
	01901013	130	1270
	01901014	130	1263
2D	01902948	89	1753
	01902034	81 *	1803
2E	21900749	90	1987
	28000065	90	1987
	21902857	86	2019
	01902027	87	2042
2F	01902031	73	2387
	01902032	73	2395
	01901695	74	2616
	01902020	83	2063
2G	01902787	82 *	2116
2H	01901055	123	2192
2I	01902666	60	811
2M	01900458	97	1196
2N	01902018	106 *	1220
	01902017	106 *	1220
	01902019	139	1213
3A	01901178	80 *	1977
	01902806	107	1993
3B	11900729	100	2206
3C	01901522	74	2486
	01901521	83	2505
3D	01901694	57	2643
3E	01900120	104	2053
	01900121	104	2065
3G	01901692	56	2698
	01901699	60	2489

Table A-3 (cont)

Cluster	Well Number	Depth to Water (feet)	Depth to Aquifer Bottom (feet)
4A	01902529	61 *	948
4B	08000049	27	2022
4C	01900001	1 *	759
4D	11900095	23	434
	01902790	17	455
4E	81902525	32	756
	81902635	40	323
4F	01901433	38	504
	01900052	25	449
4G	41900745	39	1497
5A	01902537	298	674
	01900831	285	784
	11900038	249 *	893
5B	01900029	238	1039
	01900117	198	1120
5C	01900034	184 *	1194
	08000060	183 *	1199
	01902169	151 *	1468
5D	01900882	157	1521
	01900883	156	1509
	01900885	129 *	1555
5E	01902971	74	1606
	61900718	63	2029
	61900719	64	2048
5F	08000039	128	1835
5G	01900035	125	1703
5H	01901598	127	1616
	01901599	127	1612
5I	01900031	92 *	1860
	71903093	110	1798
	71900721	106	1806
5J	51902858	115	1968
	51902947	91	1939
5K	08000093	90 *	1652
	01903067	90 *	1652
5L	01902951	81 *	1980
5M	91901439	93	1255
	91901440	70	897
	98000068	70	917
5N	01900337	92	1265
5P	01901627	75	2475
5Q	01902117	247	828

Table A-3 (cont)

Cluster	Well Number	Depth to Water (feet)	Depth to Aquifer Bottom (feet)
5X	01902581	67	1741
	01902582	67	1721
	01903072	70	1684
5Y	01903081	70	2469
	01902967	72	2459
	01903057	75	2441
6A	31902820	18	486
	31902819	21	493
	01901617	22	410
6B	01901621	25	388
	01901625	16	359
7A	01902270	74	197
	01902271	59	225

Notes: Depths to water interpolated from 1986 Water Level Contour Map (LACFCD, 1986) unless marked with an (*), indicating the 1980 contour map was used. Depths to aquifer bottom interpolated from DWR, 1966 contour map.

A.4.0 OPERABLE UNIT ALTERNATIVE IDENTIFICATION

The well clusters have been assembled into OUs that generally address specific remedial objectives. In addition to addressing remedial objectives, other factors considered in assembling well clusters into OUs include estimated depth of contamination, screened intervals of well clusters, well capacity, operational status of wells, and contaminant concentrations within the well clusters.

Table A-4 is an identification matrix in which proposed OUs have been categorized in terms of remedial objectives. The remedial objectives are not necessarily independent and, in most cases, an OU designed to primarily satisfy a particular objective will also meet most of the other objectives to some degree. For example, an OU with the primary objective of contaminant removal may also improve local water supply by alleviating a potential supply problem, as well as provide a degree of localized contaminant migration control. As explained in Section 4.0, this is consistent with a multiple-objective approach in which individual OUs will address a variety of objectives to some degree. However, because of (1) the different priority of different objectives in different parts of the basin, and (2) the inability at present to address ambitious objectives in every part of the basin, it is in many cases desirable to conceptually design OUs to primarily address one objective. Therefore, in Table A-4, OUs are listed under their primary objective. This does not imply that they do not partially satisfy the other objectives. In fact, as will be shown in subsequent appendices, some OUs designed to meet a particular objective actually appear to more effectively address other objectives.

The potential OUs are illustrated and described by RI Area in the following section. The number of potential OUs identified in a particular area is variable. The largest number of OUs is proposed in Area 5, because the largest number of production wells and largest identified region of contamination occurs in this area. Conversely, little contamination has been identified in Areas 1 and 7; and, therefore, few OU alternatives have been identified.

A.5.0 AREA-SPECIFIC IDENTIFICATION OF OPERABLE UNITS

The following sections summarize OUs identified for each of the RI areas in the San Gabriel Basin, organized by area and preceded by a summary of the extent of contamination and the hydrogeology of that area. The OU descriptions include brief discussions of some of the RIs probably required prior to implementation of each alternative. Nitrate contamination is also addressed in cases where nitrates have been detected within one-half mile upgradient.

The RI actions discussed are generally only those considered above and beyond what is typically required for implementation of actions of this type. These discussions will describe "additional" RI efforts and should not be considered to

TABLE A-4
OPERABLE UNIT IDENTIFICATION MATRIX

OBJECTIVE / AREA	PREVENT EXPOSURE	WATER SUPPLY	PROTECT GROUNDWATER RESOURCE	MANAGE CONTAMINANT MIGRATION	CONTAMINANT REMOVAL
AREA 1				1E 1D	1ABCE
AREA 2		2N		2FH 2J 2LM	2BCFH 2BCFK 2A-I,M
AREA 3		3D		3F	3BD 3BDEG
AREA 4		4E		4K 4I	4IJ 4H5R4A-G
AREA 5		5MN 5CDG	5W	5FGHT 5IJ 5P 5S	5CDI 5DGTUV 5L 5TUV 5A-J,L-MPQXY
AREA 6	6SJC*	6AB		6E	6CDFG
AREA 7				7B	7A

* SJC = SAN JOSE CREEK

EXPLANATION OPERABLE UNITS ARE GROUPED BY RI AREA AND BY PRIMARY REMEDIAL OJBECTIVE.
MOST OPERABLE UNITS ADDRESS MOST REMEDIAL OBJECTIVES TO SOME DEGREE.

F:\FIGURES\LA062440.TP\TABA-4.DWG

include every type of assessment necessary. The RI efforts not always described in the following sections include detailed sampling of every well to be affected by the action, and numerical modeling of groundwater flow and contaminant transport.

A.5.1 AREA 1

Area 1 consists of recharge areas underlain by alternating layers of high-permeability and low-permeability sediments. There are two possibly separate contaminated zones exceeding standards although, based on the locations of the data points, the boundaries of these zones of contamination are less than the resolution limits of current estimates of the extent of contamination. (Contour maps of VOC contamination are based on data points--primarily production wells--that are spaced an average one to two miles from each other. Therefore, the uncertainty of the contour maps may range up to two miles.) The wells in Area 1 reach to near the bottom of the aquifer; there may be some indication that concentrations decrease with depth. The PCE and DCE occur in the northernmost zone, and TCE is found in the southernmost zone. Scattered low levels of TCE have also been detected. There are also two zones of nitrate contamination in Area 1, one in the western portion and one in the north. As indicated in Table A-1, five potential well clusters have been identified in Area 1. Four of the clusters contain existing wells, and one cluster consists of new wells. One well in Cluster 1E is currently shut down because of VOC contamination; the maximum measured VOC value in Area 1 of 23 ug/l PCE was detected in this well. Just upgradient from the contaminated areas are a landfill and a small industrial area. No contaminant source areas have been located within Area 1 to date.

Three OUs have been proposed in Area 1 as shown in Figure A-1. These alternatives are summarized below.

A.5.1.1 1ABCE Main Objective: Contaminant Removal

OU 1ABCE consists of all existing well clusters within Area 1. Two of these wells have been removed from service because of contamination. This OU provides the maximum contaminant removal using existing wells. Water supply would be increased by about 1,740 gallons per minute (gpm) by pumping these wells at their capacity. Pumping from all the wells could spread the contaminated zones into areas not currently contaminated, and could draw nitrates towards the production wells.

The RI needs associated with this OU include depth-specific sampling (DSS) of existing wells 01901681 and 01902876.

A.5.1.2 1D Main Objective: Manage Contaminant Migration

OU 1D consists of two new extraction wells and would address the same contaminant migration objective as OU 1E (described below). Two new extraction wells are proposed just downgradient of the 1E wells (Figure A-1) and would be used to manage contaminant migration instead of using the existing wells. The RI needs are the same as for OU 1E; that is, DSS of existing wells 01901681 and 01902876. Based on the RI results, it is intended that OU 1D wells would extract groundwater from relatively shallow intervals, and that these wells would be installed if it is not feasible to modify the OU 1E wells to selectively extract the shallow groundwater. Based on available data, the two new wells are expected to be about 400 feet deep and produce about 750 gpm.

The new wells would provide an additional 1,500 gpm to the water supply if pumped at capacity. Increased pumping could potentially draw the nitrate contamination towards the production wells.

A.5.1.3 1E Main Objective: Manage Contaminant Migration

The two wells in this cluster are located near the downgradient end of the two above Action Level (AL)/MCL areas of contamination in Area 1.

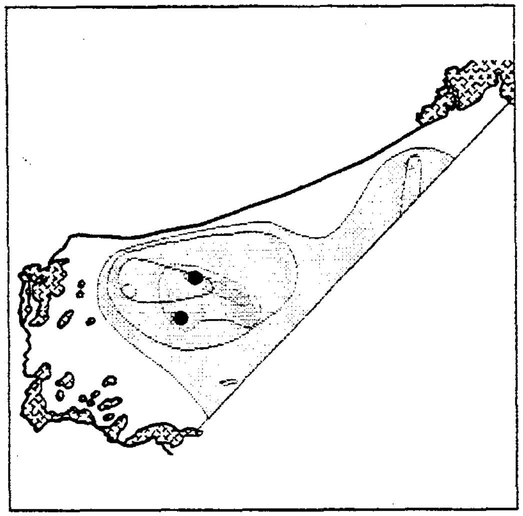
One of the wells (01901681) has been removed from service because of contamination. The primary objective of this OU is to control contaminant migration, although the contaminant removal objective would also be addressed to some degree.

Potential RI needs for this OU are DSS in wells 01901681 and 01902786 to assess the vertical distribution of contaminants. Samples from nearby wells which are perforated over deeper intervals have not indicated any contamination, suggesting that groundwater contamination may be limited to the upper portions of the aquifer. If DSS confirms strictly shallow contamination, screened intervals of OU 1E wells could possibly be altered to extract from more contaminated intervals.

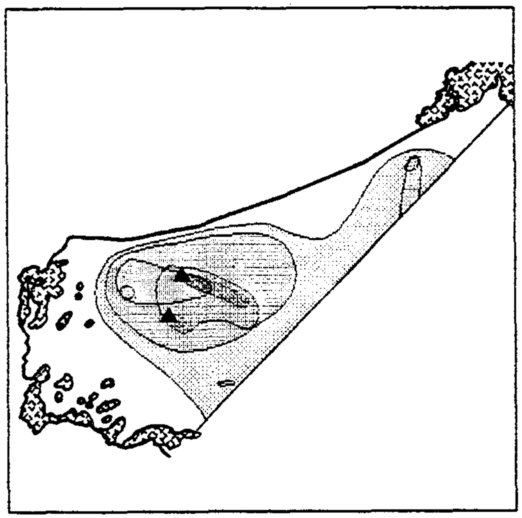
If well 01901681 is returned to service, additional pumping could pull the nitrate contamination towards the uncontaminated pumping wells in this area. Well 01901681, in the past, has had nitrate detected above the MCL of 45 milligrams per liter (mg/l).

A.5.2 AREA 2

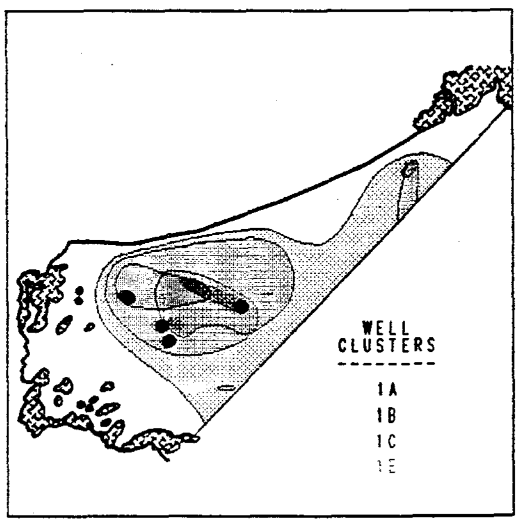
The northern portion of Area 2 is an unlayered high-permeability recharge area. The southern portion of the area, towards Whittier Narrows, is a layered



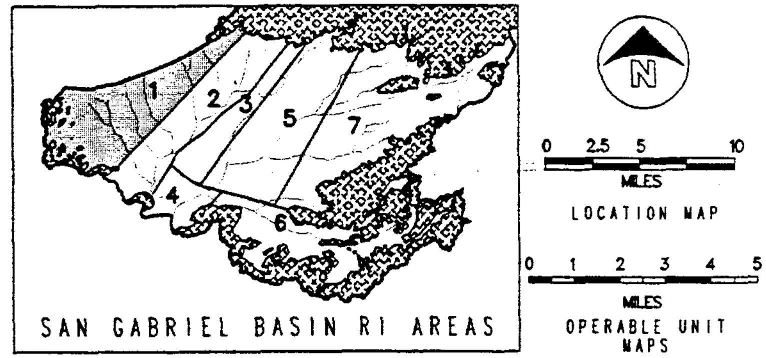
OU 1E



OU 1D



OU 1ABCE



LEGEND

- EXISTING WELL
- PROPOSED WELL
- BEDROCK OUTCROP
- RI AREA BOUNDARY
- SURFACE DRAINAGE
- HYDROLOGIC BOUNDARY
- ALLUVIAL BASIN BOUNDARY
- VOC CONTAMINATION POTENTIALLY EXCEEDING 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM MCLs TO 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM LABORATORY DETECTION LIMITS TO MCLs
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 90 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 45 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 20 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 5 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING LABORATORY DETECTION LIMITS

VOC NOTE: THE AREAS OF CONTAMINATION SHOWN IN THIS FIGURE REPRESENT GENERALIZED TWO-DIMENSIONAL APPROXIMATIONS BASED ON THE WATER QUALITY ANALYSES FROM PRODUCTION WELLS THAT VARY IN DEPTH AND PERFORATED INTERVALS. DUE TO POSSIBLE VERTICAL ZONATION OF CONTAMINATION, A WELL LOCATED WITHIN AN IDENTIFIED AREA OF CONTAMINATION MAY PRODUCE WATER WITH CONTAMINANT CONCENTRATIONS DIFFERENT THAN THAT INDICATED ON THIS MAP. AREAS OF CONTAMINATION ARE BASED ON AVAILABLE DATA FOR THE TIME PERIOD OF AUGUST 15, 1987 THROUGH MARCH 15, 1989, OR THE LAST RECORD FOR WELLS NOT SAMPLED IN THAT TIME PERIOD.

NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-1

AREA 1 OPERABLE UNITS

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San Gabriel Basin

discharge area. There are five possibly separate zones of contamination exceeding standards. The downgradient extent of these zones is relatively poorly defined, constrained to within 2 miles. The lateral extent may be defined to within about plus or minus one-half mile. Some of the zones are defined by only a few wells, so that the concentrations within the estimated extent are also uncertain. Contaminated wells in Area 2 typically tap less than half the depth of the aquifer, and some of the more shallow wells have higher concentrations than the deeper wells. TCE and PCE occur throughout the large zone of contamination; DCE, DCA, and TCA are mostly limited to the northeast part of this zone, although DCE and some CTC have been detected in the southern part of this zone. The other zones of contamination consist mostly of TCE and/or PCE, although some TCA has been detected near the southeast zone. There is a zone of nitrate contamination in the northern portion of the area and another zone in the central portion of Area 2.

In the northern part of Area 2, there is an industrial area that may contain sites that have contributed to the large area of contamination. In the southern portion of Area 2, several industrial sites have been located; and site investigation activities are underway at these sites.

As summarized in Table A-1, 11 existing well clusters and 3 new well clusters have been identified in Area 2. Clusters 2B, 2C, 2F, 2G, and 2I all contain wells that have been removed from service because of VOC contamination. Two wells in Cluster 2C have had an air stripper installed.

There are seven proposed OUs in Area 2 (Figures A-2a and A-2b); four use existing well clusters, one uses a new well cluster, and two combine new and existing well clusters. No source control or surface water OUs have been identified in Area 2.

A.5.2.1 2BCFH Main Objective: Contaminant Removal

Existing well Clusters 2B, 2C, 2F, and 2H have the highest levels of detected contaminants within the large area of contamination in Area 2. It is anticipated that these wells will be continuously pumped to maximize the removal of contaminants from the aquifer. The areal distribution of these well clusters suggests that this OU may provide a degree of contaminant migration control. Clusters 2A, 2D, and 2E could possibly be removed from service to concentrate contaminant removal at the selected clusters.

The RI needs for this OU include DSS at wells 01902027 and 01902019 to assess the vertical distribution of contaminants in this area, and resampling of wells in Clusters 2B and 2F for which recent data are not available. The perforated intervals of the existing wells could be altered based on the results of DSS to enhance contaminant removal. Nitrates are present in the 2B and 2C area, and 2B and 2C are near the estimated margin of the contaminated zone. Increased production could reduce the contaminant removal potential as clean water is drawn towards the area.

A.5.2.2 2BCFK Main Objective: Contaminant Removal

This OU is similar to 2BCFH except that existing Cluster 2H is replaced with proposed new well 2K. The new well would be located immediately downgradient of the estimated end of the greater than 50 ug/l area of contamination near the central portion of Area 2. The new well 2K is located at a proposed site for an Area 2 RI monitoring well. As in OU 2BCFH, Clusters 2A, 2D, and 2E, as well as 2H, could be removed from service. If all proposed clusters are removed from service, and the OU wells pumped at capacity, there would be an increase of about 780 gpm to current water supply rates.

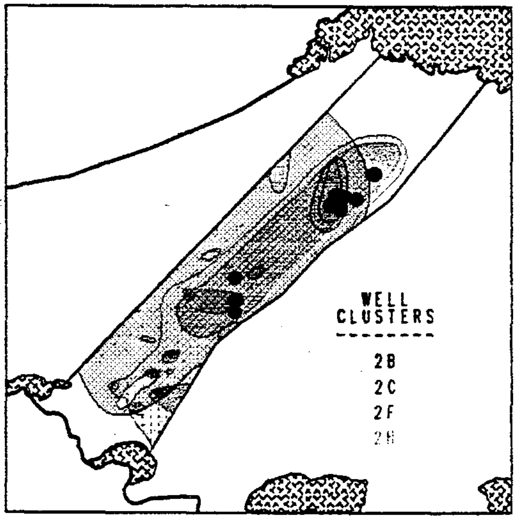
Potential RI needs include DSS of wells 01902027, 01902019, and the proposed 2K monitoring well to better define the vertical extent of contamination. Sampling is required for wells in 2B and 2F that have not been sampled for several years. Perforated intervals in existing wells could be modified based on DSS results to enhance contaminant removal. Nitrates are present in Clusters 2B and 2C at levels exceeding the MCL of 45 mg/l.

A.5.2.3 2FH Main Objective: Manage Contaminant Migration

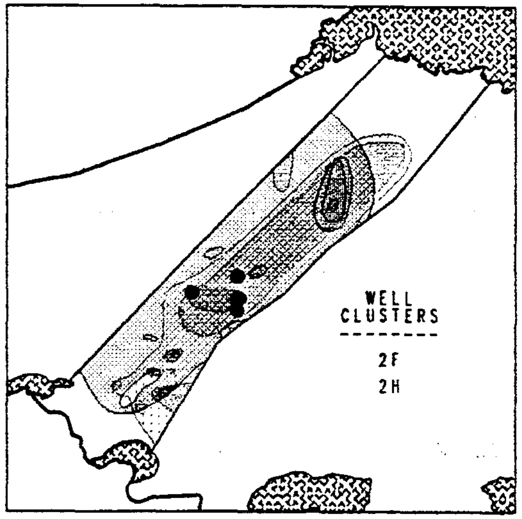
Well Clusters 2F and 2H are located towards the downgradient end of the contaminated zone. Potential RI needs for this OU are the same as for OU 2BCFH and include DSS of wells 01902027 and 01902019. In addition, the 2F wells, for which recent data are not available, should be resampled. If the RI results suggest significant contamination at a depth greater than the screened intervals of the 2F wells (about 350 feet), this OU may not provide effective containment for migration beneath the vertical zone of influence of the pumping wells. Nitrates have been detected in the well clusters.

A.5.2.4 2J Main Objective: Manage Contaminant Migration

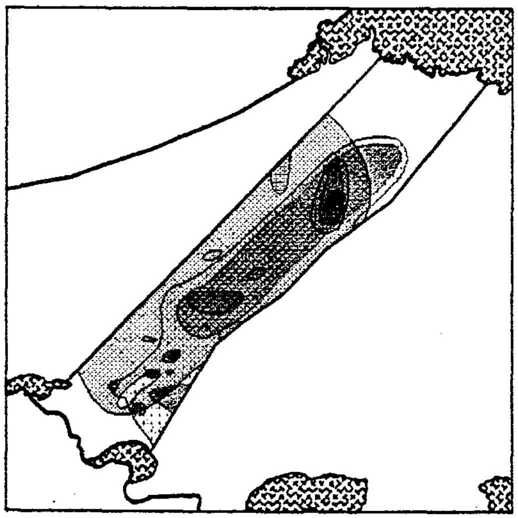
OU 2J consists of three new extraction wells located immediately downgradient of the large area of contamination. It is anticipated that the depth of the new wells would be on the order of 800 feet, and that well capacities would be approximately 3,000 gpm. The first well would be drilled and sampled as a pilot hole. In addition, RI requirements include DSS at well 01901055 and installation and sampling of the 2K RI monitoring well. An additional water supply of 9,000 gpm could result from this OU.



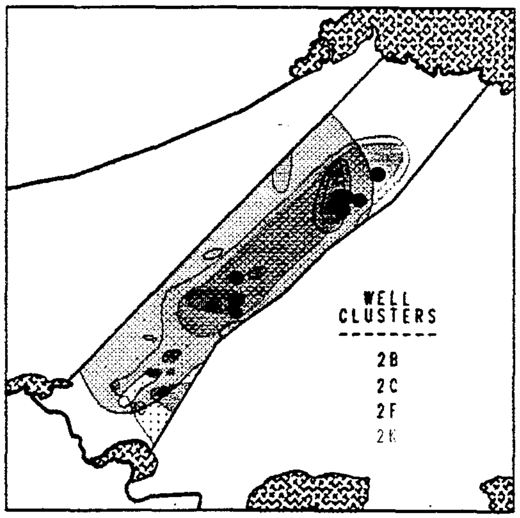
OU 2BCFH



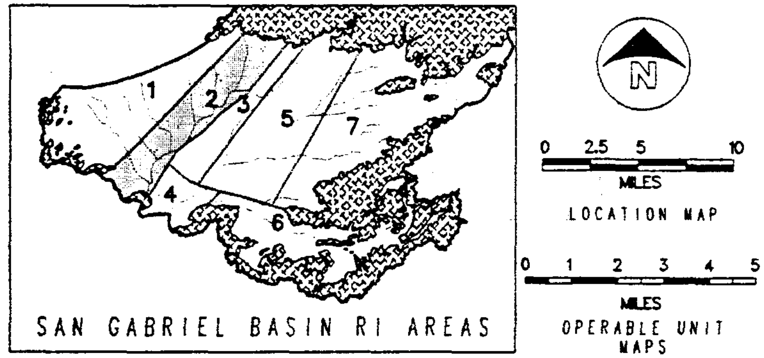
OU 2FH



OU 2N



OU 2BCFK



LEGEND

- EXISTING WELL
- PROPOSED WELL
- BEDROCK OUTCROP
- RI AREA BOUNDARY
- SURFACE DRAINAGE
- HYDROLOGIC BOUNDARY
- ALLUVIAL BASIN BOUNDARY
- VOC CONTAMINATION POTENTIALLY EXCEEDING 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM MCLs TO 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM LABORATORY DETECTION LIMITS TO MCLs
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 90 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 45 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 20 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 5 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING LABORATORY DETECTION LIMITS

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NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-2a

AREA 2 OPERABLE UNITS (1 of 2)

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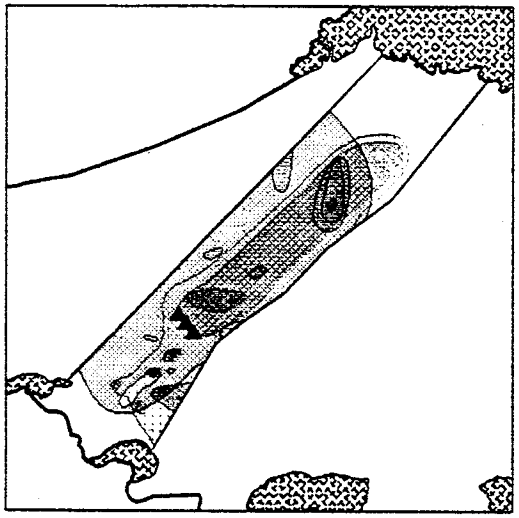
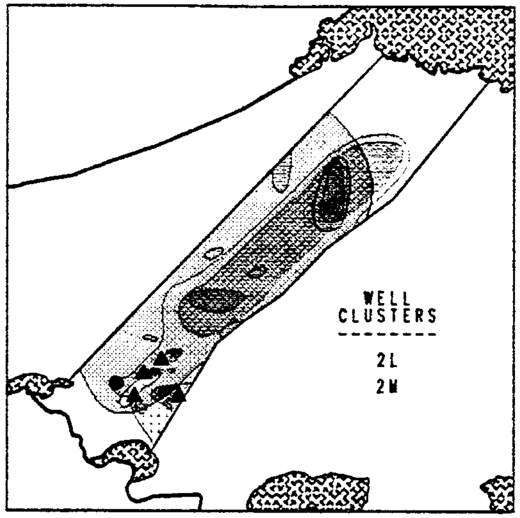
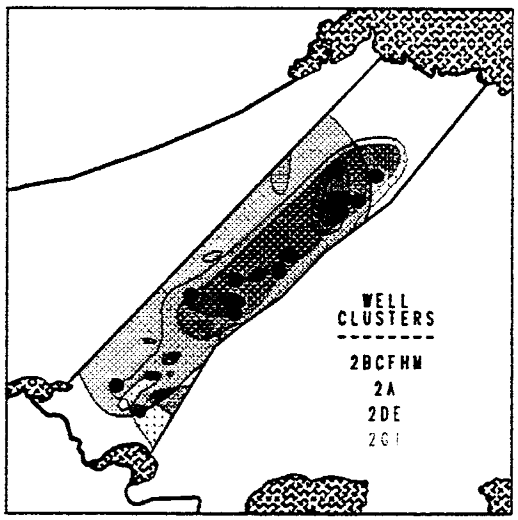


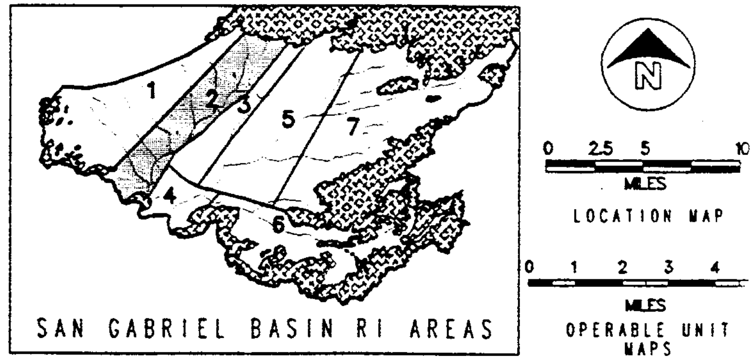
OU 2J



OU 2LM



OU 2A-1,M



LEGEND

- ● EXISTING WELL
- ▲ PROPOSED WELL
- BEDROCK OUTCROP
- RI AREA BOUNDARY
- SURFACE DRAINAGE
- HYDROLOGIC BOUNDARY
- ALLUVIAL BASIN BOUNDARY
- VOC CONTAMINATION POTENTIALLY EXCEEDING 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM MCLs TO 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM LABORATORY DETECTION LIMITS TO MCLs
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 90 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 45 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 20 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 5 PPM
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NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-2b

AREA 2 OPERABLE UNITS (2 of 2)

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San Gabriel Basin

A.5.2.5 2LM Main Objective: Manage Contaminant Migration

OU 2LM consists of four new extraction wells (2L) and one existing well (2M) located downgradient of the five apparently limited areas of contamination in the southern portion of Area 2. Managing migration in this area may provide protection to the major pumping center in the southwest corner of Area 2. Because there are few production wells located in this portion of Area 2, additional information from ongoing site investigations regarding the lateral and vertical extent of contamination is required for additional RI needs.

Because the contamination in this area is thought to be relatively shallow, the new wells are estimated to be on the order of 200 feet deep and produce about 500 gpm. The scope of this OU could change if additional site investigations indicate that the contaminated areas are more numerous or extensive than presently thought (Figures A-2a and A-2b).

A.5.2.6 2N Main Objective: Water Supply

The three wells in Cluster 2N (which are also included in either Cluster 2B or 2C) have all been removed from service because of VOC contamination. Based on available data, returning these wells to service could provide an additional capacity of about 4,110 gpm. In addition to improving water supply, the contaminant removal objective would also be addressed by this OU. The RI needs associated with this OU include resampling of wells for which recent data are not available. Nitrates have been detected above the MCL in these three wells.

A.5.2.7 2A-I,M Main Objective: Contaminant Removal

All existing well clusters in Area 2 are included in this OU. This OU provides the maximum contaminant removal possible using only existing wells. Contaminant migration would also be controlled to some extent, and the water supply would be increased by about 7,120 gpm if the OU wells are pumped at capacity.

The RI needs include those associated with identifying treated water disposal options, and DSS at 019902019, 01902027, and 01901055 to estimate the vertical distribution of contaminants. Some wells in Clusters 2B, 2F, and 2G have not been sampled in several years, and will require resampling. Nitrates have been identified at concentrations greater than the MCL in some of these wells, and continuous pumping of wells previously removed from service could draw nitrates into previously uncontaminated wells.

A.5.3 AREA 3

Northern Area 3 is an unlayered high-permeability recharge area while the southern section is a layered discharge area. There may be two zones with contamination above 50 ug/l within two larger zones above standards. The separation of the upper zone from the large zone in Area 2 is tenuously based on only one shallow well. The lateral extent to the southeast is poorly defined, as few wells exist between the estimated edge of the contaminated zone and the San Gabriel River. The downgradient extent is similarly poorly defined; connection with the zone of contamination in the southeast part of Area 3 is uncertain. Uncertainty in the downgradient extent is up to 2 miles. An area of nitrate contamination has been identified in the southwest portion of Area 3.

Seven well clusters have been identified in Area 3 (Table A-1). Six of these clusters consist of existing wells, and one cluster consists of a new well. Well Cluster 3B represents the water supply well owned by the Richwood Mutual Water Company. As previously mentioned, this well has been identified as an OU, and a treatment system has been installed. Cluster 3A represents a well owned by the Hemlock Mutual Water Company; an activated carbon treatment system has been installed on this well. One well has been shut down because of VOC contamination in Cluster 3D. Most of the contaminated wells in this area are perforated above 300 feet, but the aquifer is over 2,000 feet thick.

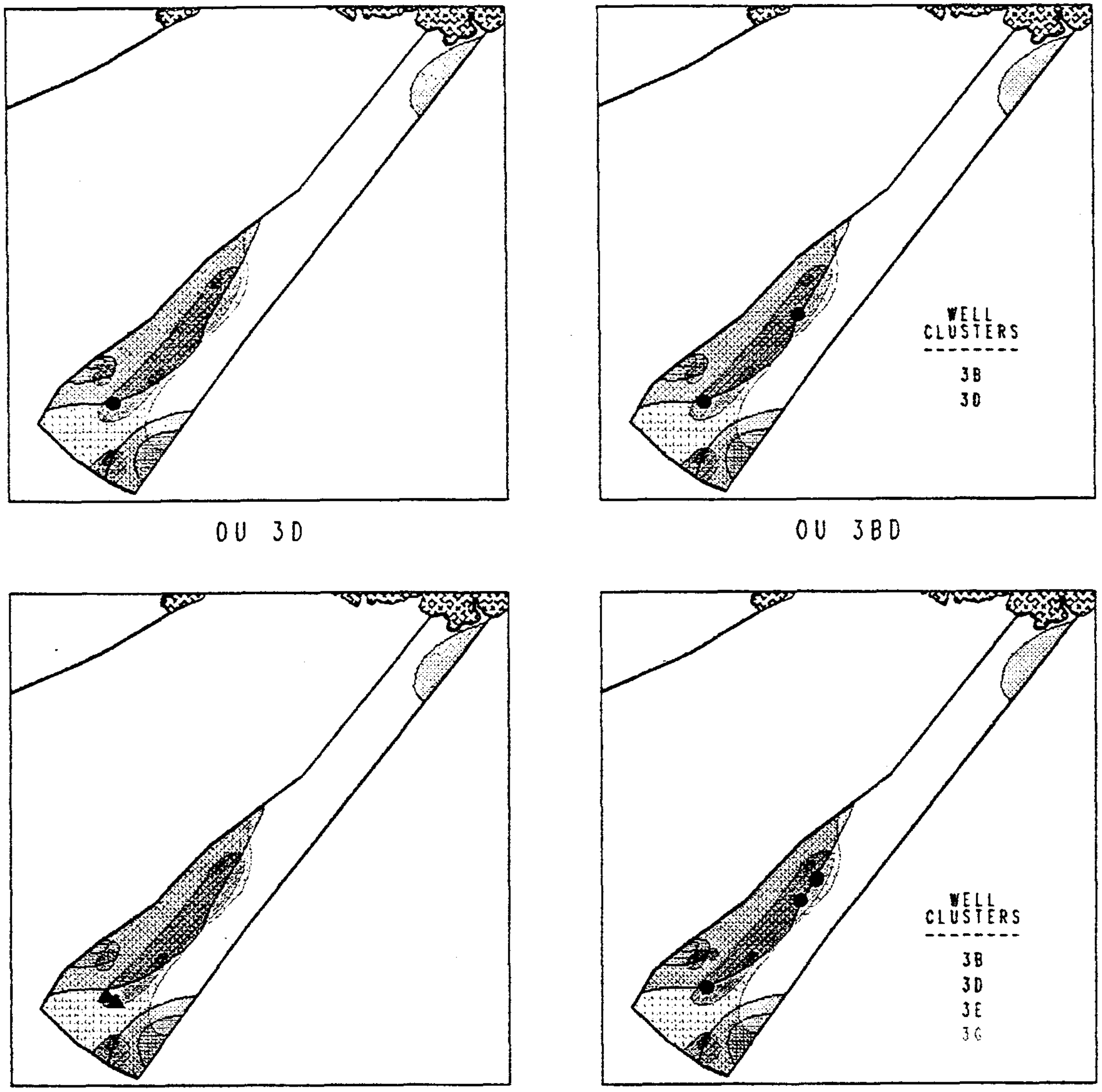
Four OUs are proposed in Area 3 (Figure A-3). Three involve existing well clusters and one uses a new well cluster.

A.5.3.1 3BD Main Objective: Contaminant Removal

Clusters 3B and 3D are located within the large area of contamination in Area 3. Contaminant levels in these clusters are currently the highest of the Area 3 wells not already being treated. Probable RI needs include data from DSS in well 11902946, located near well 3B, and 01901699 in cluster 3G to assess the depth and vertical distribution of contamination. Though well 11902946 (screened from 240 to 506 feet) has shown only low levels of contaminants, DSS will delineate any intervals containing higher levels of contamination. Well 3D, which has not been sampled in 4 years, will need to be resampled. If DSS indicates that contamination is predominantly shallow, well 3D could potentially manage contaminant migration to a degree. Nitrate contamination in the area presents a potential problem.

A.5.3.2 3D Main Objective: Water Supply

Existing well 3D (01901694) is the only well in Area 3 currently removed from service because of VOC contamination. Because this well is located near the downgradient end of the main contaminated zone in Area 3, A 3D could ultimately be augmented with additional new wells to manage downgradient

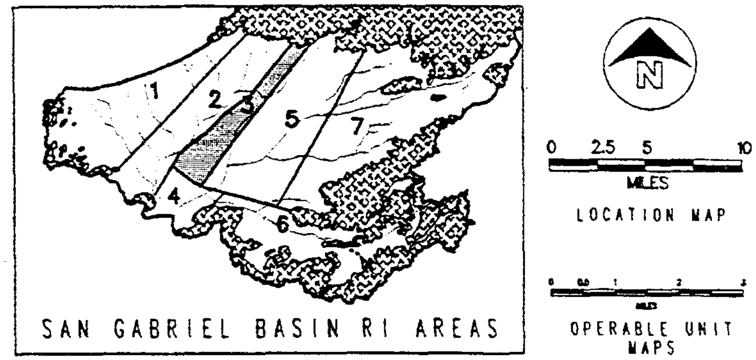


OU 3D

OU 3BD

OU 3F

OU 3BDEG



LEGEND

- EXISTING WELL
- PROPOSED WELL
- BEDROCK OUTCROP
- RI AREA BOUNDARY
- SURFACE DRAINAGE
- HYDROLOGIC BOUNDARY
- ALLUVIAL BASIN BOUNDARY
- VOC CONTAMINATION POTENTIALLY EXCEEDING 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM MCLs TO 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM LABORATORY DETECTION LIMITS TO MCLs
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 90 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 45 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 20 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 5 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING LABORATORY DETECTION LIMITS

VOC NOTE: THE AREAS OF CONTAMINATION SHOWN IN THIS FIGURE REPRESENT GENERALIZED TWO-DIMENSIONAL APPROXIMATIONS BASED ON THE WATER QUALITY ANALYSES FROM PRODUCTION WELLS THAT VARY IN DEPTH AND PERFORATED INTERVALS. DUE TO POSSIBLE VERTICAL ZONATION OF CONTAMINATION, A WELL LOCATED WITHIN AN IDENTIFIED AREA OF CONTAMINATION MAY PRODUCE WATER WITH CONTAMINANT CONCENTRATIONS DIFFERENT THAN THAT INDICATED ON THIS MAP. AREAS OF CONTAMINATION ARE BASED ON AVAILABLE DATA FOR THE TIME PERIOD OF AUGUST 15, 1987 THROUGH MARCH 15, 1989, OR THE LAST RECORD FOR WELLS NOT SAMPLED IN THAT TIME PERIOD.

NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-3

AREA 3 OPERABLE UNITS

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San Gabriel Basin

contaminant migration. The zone of nitrate contamination is near this well. The RI efforts required include sampling of well 3D which has not been sampled in almost 4 years.

A.5.3.3 3BDEG Main Objective: Contaminant Removal

This OU utilizes all existing well clusters not already receiving wellhead treatment, and provides the maximum contaminant removal possible using existing wells. Water supply could be increased by about 1,330 gpm if the OU wells are pumped at capacity.

The RI needs identified for this OU include DSS at wells 11902946, 01901694, and 01901699. Nitrates are present in this area and will probably have to be considered in the selection of a treatment system.

A.5.3.4 3F Main Objective: Manage Contaminant Migration

OU 3F consists of two new wells located at the downgradient end of the large zone of contamination in Area 3. Based on available data, it is assumed that the proposed new wells would be on the order of 600 feet deep and would pump at about 2,500 gpm.

The downgradient end of the Area 3 zone of contamination is not well defined, and a RI monitoring well has been proposed between this zone and the southeast zone to determine if the two areas are connected. The probable RI needs for this OU include data from the proposed RI well and DSS at wells 11902946 and 01901699. Nitrate contamination in the area presents a potential problem.

A.5.4 AREA 4

Area 4 is a layered discharge area with two relatively large zones of VOC contamination. Area 4 has three zones above standards in Whittier Narrows and four smaller zones in the northern portion that exceed 50 ug/l. One of the three larger zones is in the northeastern portion of Area 4 and originates in Area 5. Connection of this zone with the eastern zone of contamination in Whittier Narrows is uncertain; only a few shallow wells separate them. The eastern zone contains TCE and PCE; DCE and TCA have been detected in some of the wells in the eastern zone. In addition, CTC was detected in one well in the northern part of the eastern zone. The western zone, which appears to originate in Area 3, is especially poorly defined as there are few deep wells; PCE occurs in shallow wells in this zone. In the northwestern portion of Area 4, where contamination is concentrated in several small zones, including two above 50 ug/l, TCE, PCE, DCE, and TCA have been detected. The complex and intensive pumping patterns in Whittier Narrows make the interpretation of sampling results difficult as significant short-term variations have been observed.

Eleven well clusters have been defined in Area 4, seven clusters with existing wells and four with proposed wells. Well clusters identified in this RI Area are summarized in Table A-1 and shown in Figures A-4a and A-4b. To date, the only wells shut down from VOC contamination in Area 4 are those of Cluster 4E. Site investigations are currently underway at several industrial sites in the northern portion of Area 4. There are also industrial areas in the eastern portion of Area 4, although no individual sites have been identified as potential sources to date.

As mentioned in Section 1.1.1, Previous and Ongoing Operable Unit Activities, two OUs have already been defined in Area 4: the Whittier Narrows OU and the Suburban Water Systems OU. The main objective of the Whittier Narrows OU is to control migration of contamination into the Central Basin. The objective of the Suburban OU is water supply.

Six additional OUs are proposed for Area 4. Two of these involve existing well clusters, and four include new well clusters.

A.5.4.1 4A-G Main Objective: Contaminant Removal

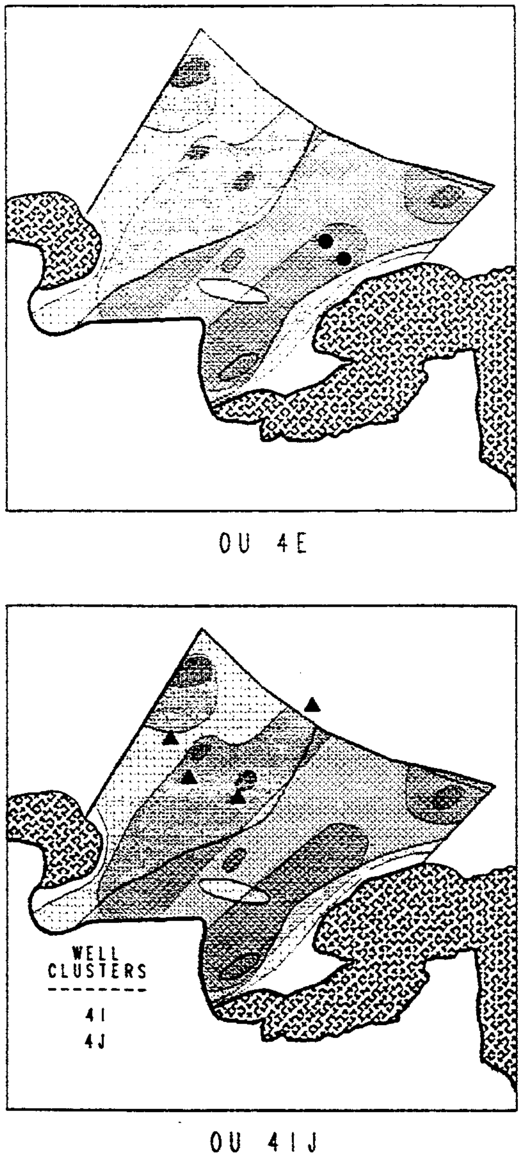
OU 4A-G includes all existing well clusters in Area 4 and provides the maximum contaminant removal possible with existing wells. Water supply would be increased by about 3,660 gpm if all OU wells are pumped at capacity. This OU would require coordination with the Whittier Narrows OU. The RI needs required for implementation of this OU include DSS sampling of the new RI monitoring well clusters in the western portion of Whittier Narrows and from the proposed monitoring well cluster to be installed by the U.S. Army Corps of Engineers.

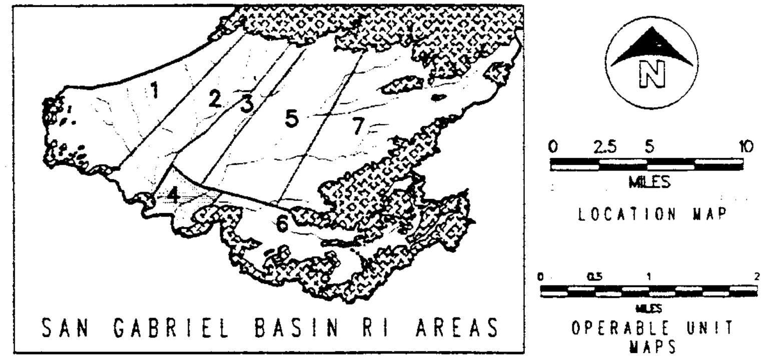
A.5.4.2 4E Main Objective: Water Supply

OU 4E consists of two existing wells, one already removed from service and one about to be removed from service because of VOC contamination. Providing treatment to the wells in this cluster would return 3,660 gpm to service. Specific RI data needs have not been identified for this OU. Data from a monitoring well cluster to be installed by the U.S. Army Corps of Engineers should provide data on the vertical distribution of contaminants in the area.

A.5.4.3 4I Main Objective: Manage Contaminant Migration

OU 4I is similar to OU 4IJ except that only the two smaller zones of contamination are considered. Cluster 4I is located downgradient of two apparently





LEGEND

- EXISTING WELL
- PROPOSED WELL
- BEDROCK OUTCROP
- RI AREA BOUNDARY
- SURFACE DRAINAGE
- HYDROLOGIC BOUNDARY
- ALLUVIAL BASIN BOUNDARY
- VOC CONTAMINATION POTENTIALLY EXCEEDING 10X MCLs
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NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-4a

AREA 4 OPERABLE UNITS (1 of 2)

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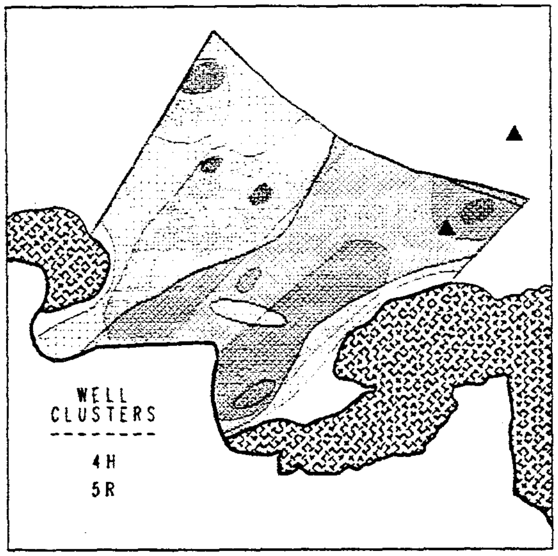
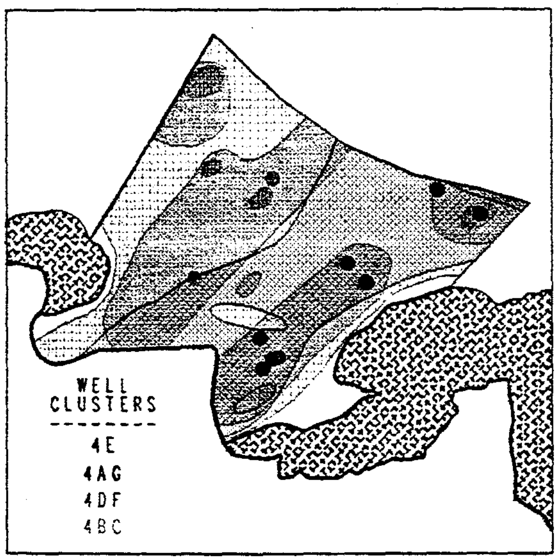
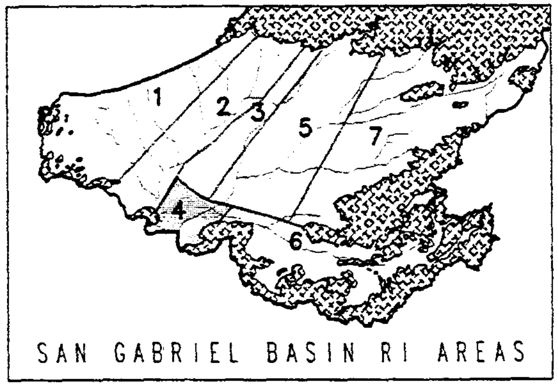
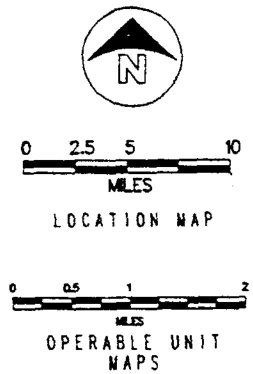


OU 4H5R



OU 4A-G





LEGEND

- ● EXISTING WELL
- ▲ PROPOSED WELL
- BEDROCK OUTCROP
- RI AREA BOUNDARY
- SURFACE DRAINAGE
- HYDROLOGIC BOUNDARY
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NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-4b

AREA 4 OPERABLE UNITS (2 of 2)

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San Gabriel Basin

limited areas of contamination in the northwestern portion of Area 4. Additional data from site investigations on the extent of contamination are required to implement this OU.

This OU could augment water supply by about 1,500 gpm. As with OU 4IJ, the scope of the OU could change if the results of site investigations indicate that the contaminated areas are more numerous or extensive.

A.5.4.4 4IJ Main Objective: Contaminant Removal

OU 4IJ consists of four new extraction wells. The cluster 4I wells are described above. Cluster 4J is located downgradient of two areas with contaminant levels exceeding 50 ug/l within a larger area of contamination. Because the contamination in these areas is thought to be relatively shallow, the new wells are proposed to a depth of approximately 250 feet with a capacity of 750 gpm. Few production wells are located in this portion of Area 4, and further information from ongoing site investigations regarding the lateral and vertical extent of contamination is required for additional RI needs.

The wells in Cluster 4I will help control contaminant migration and supplement the local water supply by about 3,000 gpm. The scope of this alternative could change if additional site investigations indicate contamination in the area to be more extensive.

A.5.4.5 4H5R Main Objective: Contaminant Removal

Clusters 4H and 5R each consist of one new well located immediately downgradient of two areas in which contaminant levels exceed 50 ug/l. Well 4H is proposed to a depth of about 400 feet with a capacity of about 1,250 gpm. Well 5R would be an estimated 300 feet deep and produce 1,000 gpm.

Probable RI requirements regarding the depth and vertical distribution of contamination include data from the monitoring well cluster to be built by the U.S. Army Corps of Engineers between Areas 4 and 6, along with a monitoring well in the southwestern portion of Area 5. An additional capacity of 2,250 gpm would result from this OU.

Only shallow wells (less than 300 feet deep) in this area have shown contamination above ALs/MCLs. The downgradient extent of individual zones of contamination are presently poorly defined, and nitrate contamination above the MCLs occurs in Area 5R.

A.5.4.6 4K Main Objective: Manage Contaminant Migration

Cluster 4K consists of three new wells located downgradient of the large zone of contamination originating in Area 5. High levels of contaminants occur in the northern portions of this zone (in Area 5). OU 4K is proposed to control further migration of contaminants towards Whittier Narrows from Area 5. The proposed new wells would also help control the migration of groundwater contamination from Area 6 towards the Whittier Narrows area. It is anticipated that the new wells would range from 300 to 700 feet deep, and could produce from 1,250 to 2,500 gpm.

Potential RI needs may be reduced considerably by obtaining data from a monitoring well cluster to be constructed by the U.S. Army Corps of Engineers between the Puente Valley and Whittier Narrows. Information regarding the vertical distribution of contaminants in the area could be augmented with a monitoring well upgradient of 4K in the southwestern portion of Area 5. This would provide data on the level and depth of contamination expected to migrate towards Cluster 4K in the future.

The local water supply would increase by about 6,250 gpm with the implementation of this OU.

A.5.5 AREA 5

Most of Area 5 is an unlayered, high-permeability recharge area. The extreme southern portion, near Whittier Narrows and Puente Valley, is a layered discharge region. There are four possibly separate zones of contamination above standards within Area 5. In the large zone of contamination (Figure 1-2) in the central part of this area, the highest levels of contamination and the most permeable sediments appear to occur. The upgradient and lateral extent in the northern portion of this zone appears well defined, although the "clean" wells that define these boundaries tend to be much deeper than the more contaminated wells within the zone. The downgradient extent along the southern portion may extend into Area 4. The paucity of wells within the zone apparently exceeding 50 ug/l makes the nature of contamination within this part of the zone uncertain. The downgradient extent of this zone is poorly defined and some connection with the other three zones in this area is possible.

Concentrations of TCE tend to be higher in the wells in the eastern part of the large zone than in the deeper wells along the western part, suggesting some variation of levels with depth. However, concentrations of PCE are highest in the deeper western wells, exceeding levels in the more shallow eastern wells. Several TCE-only wells, with levels below the AL, occur just outside the large zone. CTC and TCA appear in both shallow and deep intervals in the southwestern portion of the main zone and in the two most southerly zones of contamination in this area. This may suggest that contaminants can flow towards both Whittier Narrows and the pumping center in southeastern Area 5. DCE seems to occur mainly in the northeastern portion of the main zone, although it has also been detected in the southwestern and southeastern zones. The nature of the contaminants in the small zone of contamination just west of the confluence of Walnut Creek and the San Gabriel River appears somewhat unique as only PCE has been detected. Nitrate contamination above 45 mg/l occurs over a large part of the eastern half of Area 5.

Nine production wells in the northern portion of the large zone of contamination are presently shut down because of VOC contamination. Several other wells have high contaminant levels, but are being treated or mixed with water from clean wells. Potential sources of contamination are located in the northern section of Area 5.

A summary of the characteristics of the 24 well clusters selected in this area is presented in Table A-1 and the locations are presented in Figures A-5a, A-5b, and A-5c. Of these, 18 consist of existing wells; and the other six are proposed new wells. Twelve OUs have been identified within Area 5. Seven are made up of existing well clusters, three consist of new well clusters, and two contain both existing and new clusters. Descriptions of each OU follow.

A.5.5.1 5CDG Main Objective: Water Supply

These three clusters offer the greatest increase in water produced while treating the fewest wells. Treating the five wells currently out of service from VOC contamination would return 14,890 gpm of capacity to the water supply system. In Cluster 5C, 08000060 (capacity 4,200 gpm) is already being treated. Additional RI needs identified for this OU include sampling of selected cluster wells that have not been sampled in several years. Nitrate contamination is a potential problem that will require consideration in the selection of a treatment system.

A.5.5.2 5CDI Main Objective: Contaminant Removal

5CDI consists of three existing well clusters. The wells have high levels of contamination and large capacities. It is anticipated that the wells could be pumped constantly at capacity to increase the contaminant removal. This OU would increase production and the water supply by 13,070 gpm from 9 wells currently out of service because of VOC contamination. Two of the wells would need to be made operable. However, the zone of nitrate contamination near these clusters presents a potential problem that will require consideration in the selection of a treatment alternative.

Probable RI needs required for implementation of this OU include DSS at three wells (01900035, 08000060, and 51902947), and installation of the RI monitoring well proposed for 5U (described below). Some of the wells in the three clusters have not been sampled in several years and will require resampling. Depending on the results of DSS, perforated intervals could be altered to enhance contaminant removal.

A.5.5.3 5DGTUV Main Objective: Contaminant Removal

This OU is similar to OU 5TUV (described below) with additional removal capacity added with the use of existing well clusters 5D and 5G. The fourexisting wells in 5D and 5G are all out of service from VOC contamination and have a total capacity of 11,290 gpm. The removal rate is slightly greater than that of OU 5TUV, and water supply could be increased by about 11,290 gpm. The proposed RI needs are the same as outlined in OU 5TUV as well as sampling of wells in Clusters 5D and 5G, which have not been sampled in several years. Screened intervals of these wells could be altered based on the results of DSS to enhance contaminant capture and removal. Nitrate contamination is present.

A.5.5.4 5FGHT Main Objective: Manage Contaminant Migration

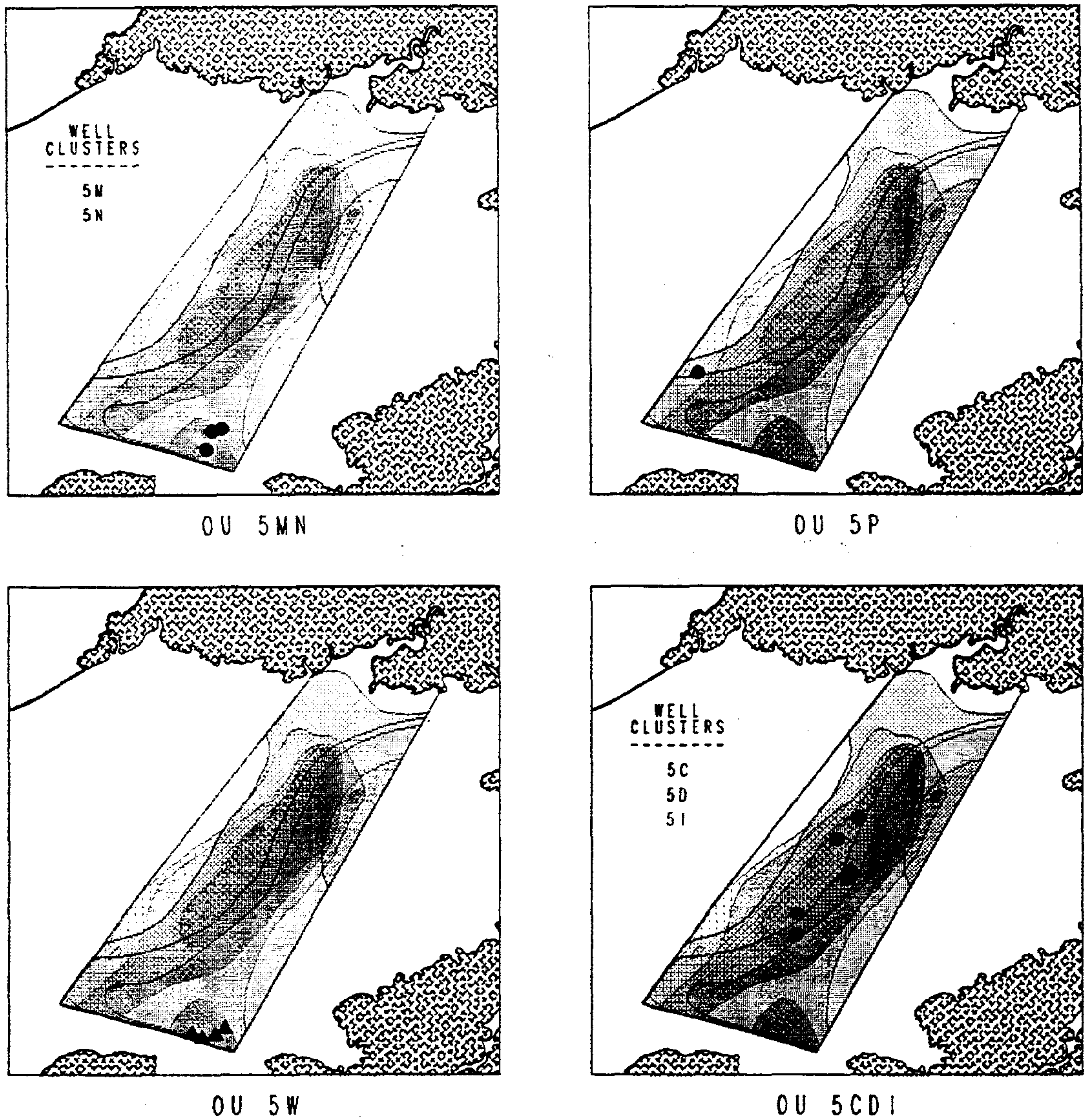
This OU consists of one new well (5T) and three existing well clusters (5F, 5G, and 5H) downgradient of the highest levels of contamination in Area 5. The purpose of this OU is to control future migration of this high-level contamination to areas of lesser contamination downgradient. The new well is a proposed monitoring well that could be converted to an extraction well about 1,000 feet deep with a capacity of 3,500 gpm. Cluster 5H on the eastern side of the area is only 350 feet deep, and Cluster 5F on the western side produces only 750 gpm, which could reduce the ability of this alternative to effectively manage migration.

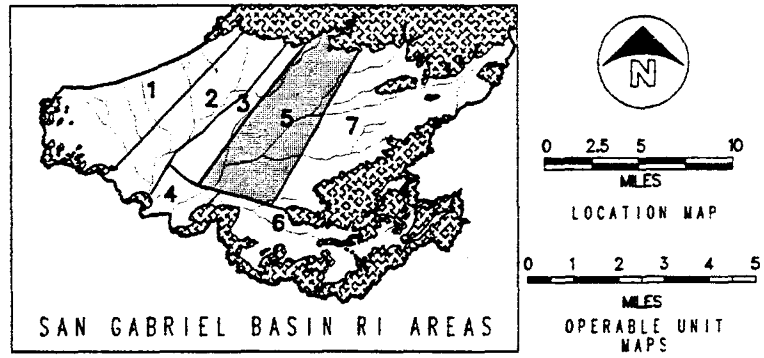
Probable RI needs include installation and sampling of well 5T and DSS sampling of two other wells (01900035 and 08000060) to assess the depth of contamination in this area. Wells in Clusters 5F and 5G have not been sampled in several years and will require resampling. An additional water supply of 3,500 gpm could become available, and 4,454 gpm could be returned to service. Nitrate levels at 5H are presently above MCLs.

A.5.5.5 5IJ Main Objective: Manage Contaminant Migration

Existing well Clusters 5I and 5J are situated towards the downgradient end of the large zone of high contamination in Area 5. The intent of this OU is to manage migration of the highly contaminated zone. One well (71900721) would need to be made operable again.

The RI needs for this OU include DSS at well 71900721 in 5I which has not been sampled in over 3 years. Other RI needs are as described in OU 5CDI and installation of the 5T monitoring well. The 5I and 5J wells are about 500 feet deep; if high contamination is detected deeper than 500 feet, these wells will not effectively intercept contamination at depth. A zone of nitrate near these wells presents a potential problem.





LEGEND

- EXISTING WELL
- PROPOSED WELL
- BEDROCK OUTCROP
- VOC CONTAMINATION POTENTIALLY EXCEEDING 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM MCLs TO 10X MCLs
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- NO3 CONTAMINATION POTENTIALLY EXCEEDING 5 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING LABORATORY DETECTION LIMITS
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NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-5a
AREA 5 OPERABLE UNITS (1 of 3)
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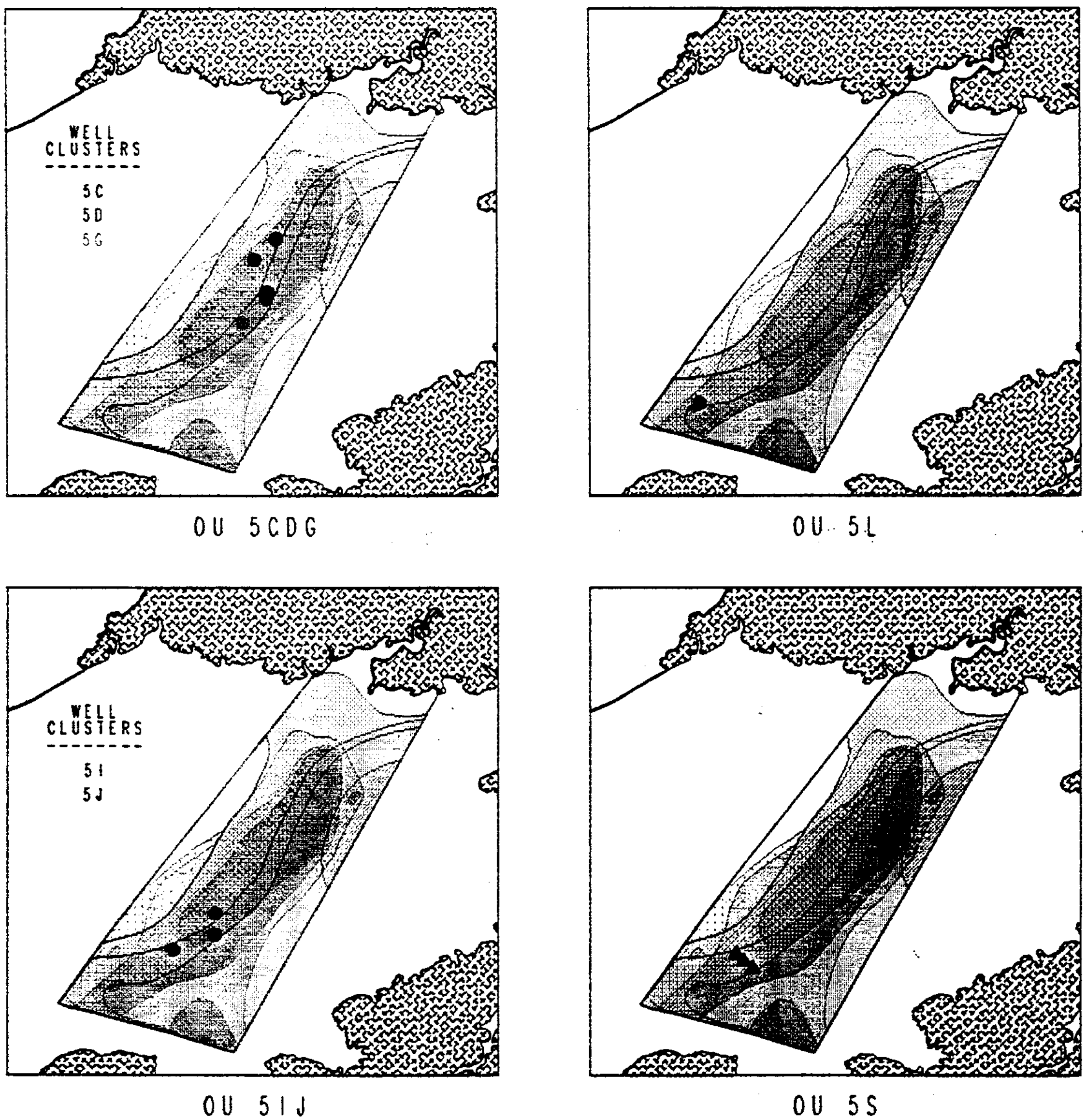

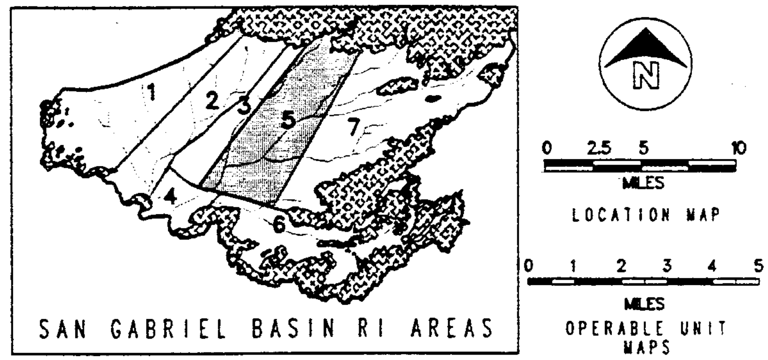

LEGEND

- EXISTING WELL
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- BEDROCK OUTCROP
- RI AREA BOUNDARY
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NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-5b

AREA 5 OPERABLE UNITS (2 of 3)

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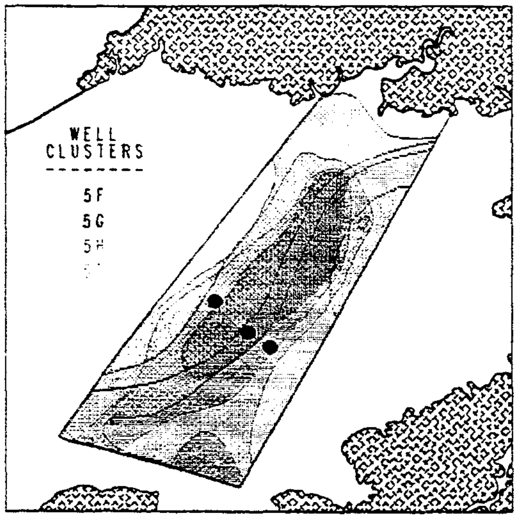
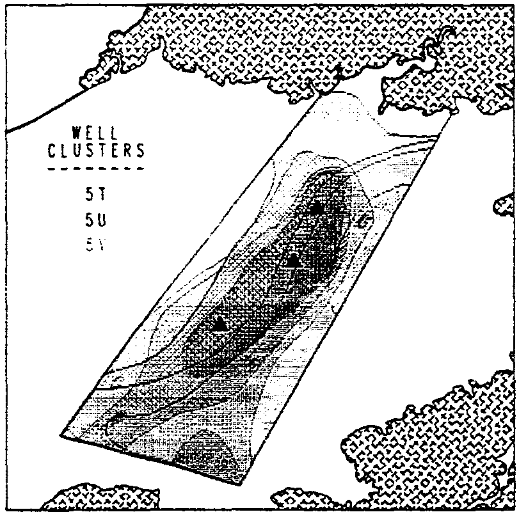
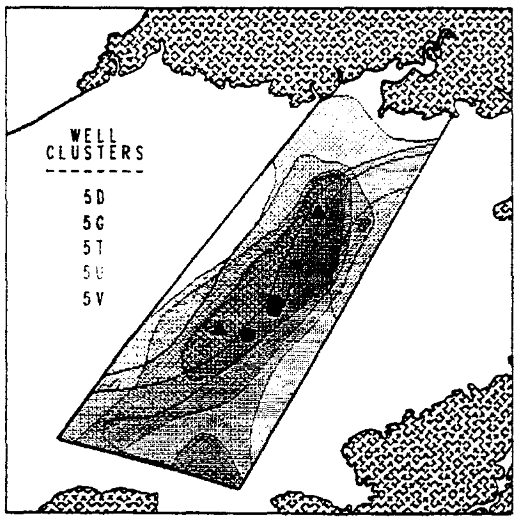


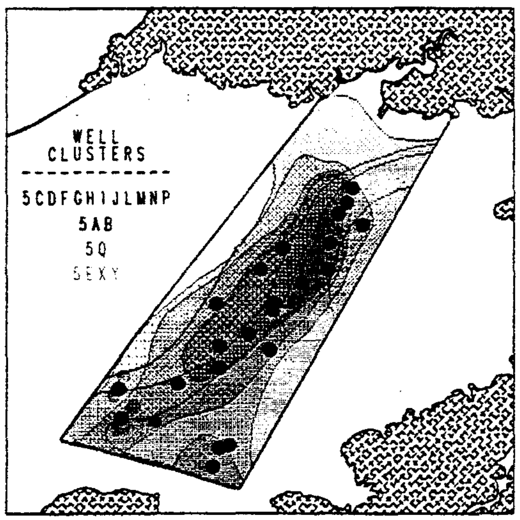
OU 5FGHT



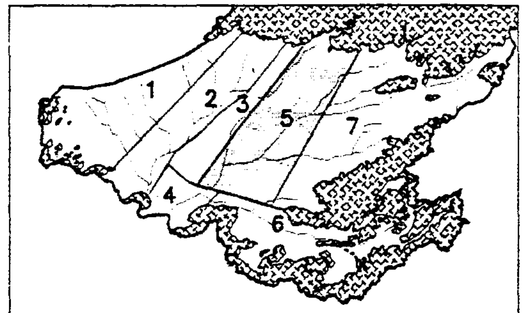
OU 5TUV



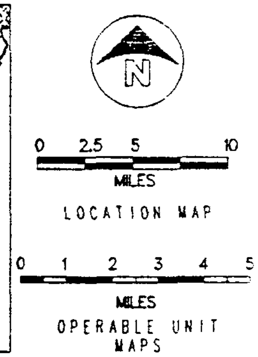
OU 5DGTUV



OU 5A-J,L-N,PQXY



SAN GABRIEL BASIN RI AREAS



LEGEND

- EXISTING WELL
- PROPOSED WELL
- BEDROCK OUTCROP
- RI AREA BOUNDARY
- SURFACE DRAINAGE
- HYDROLOGIC BOUNDARY
- ALLUVIAL BASIN BOUNDARY
- VOC CONTAMINATION POTENTIALLY EXCEEDING 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM MCLs TO 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM LABORATORY DETECTION LIMITS TO MCLs
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 90 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 45 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 20 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 5 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING LABORATORY DETECTION LIMITS

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NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-5c

AREA 5 OPERABLE UNITS (3 of 3)

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San Gabriel Basin

A.5.5.6 5L Main Objective: Contaminant Removal

The existing well in cluster 5L is located in a zone in which contaminant levels exceed 50 ug/l. The well could be pumped continuously at capacity to enhance contaminant removal.

The downgradient margin of the greater-than-50 ug/l zone is not well defined. Probable RI needs require continued monitoring at 4G to determine if this highly contaminated area is migrating downgradient or is larger than presently estimated. The capacity of the 5L well is only 250 gpm. If the contaminated zone is larger than anticipated, the well may not remove enough contamination to make this OU practical. Potential nitrate contamination is likely.

A.5.5.7 5MN Main Objective: Water Supply

Clusters 5M and 5N contain four active contaminated wells located in a pumping center in the southeastern portion of Area 5. Another three contaminated wells in this area have been abandoned. The contaminated water produced by the active wells is blended with clean water from other wells. If blending ceases to be feasible as contaminant levels increase, this alternative could be implemented to augment the water supply. The RI data need identified include DSS of well 98000108 to assess the vertical distribution of contaminants. A zone of nitrates contamination nearby presents a potential problem.

A.5.5.8 5P Main Objective: Manage Contaminant Migration

The 5P well is located toward the downgradient end of a small area of contamination. It is anticipated that the well would be pumped at the maximum capacity to inhibit further migration of the contamination and to maximize contaminant removal in this area. Well 5P alone may not effectively manage contaminant migration in this area. The RI data needs require continued monitoring of wells surrounding 5P, which is necessary to monitor the effectiveness of this alternative.

A.5.5.9 5S Main Objective: Manage Contaminant Migration

OU 5S consists of three new wells located immediately downgradient of the area of high contamination in Area 5. Existing wells may not be deep enough or located properly to manage migration of this zone of contamination. This OU would include drilling new wells to depths of about 1,000 feet to produce approximately 3,500 gpm each.

Extensive RI needs are associated with this OU including DSS of three wells (01900035, 08000060 and 51902947) and installation of two monitoring wells.

One monitoring well is part of Cluster 5T, and the other well would be located to the south near cluster 5E.

An additional 10,500 gpm of water supply could be created by this OU. Nitrate contamination is considered likely in the proposed new wells.

A.5.5.10 5TUV Main Objective: Contaminant Removal

OU 5TUV consists of three new clusters with one well each located in the greater-than-50 ug/l area. New monitoring wells are proposed near the sites of wells 5T and 5U. Continuous pumping at capacity is proposed to maximize the removal of contaminants from the area. Each extraction well would be about 1,000 feet deep and produce about 3,500 gpm.

Proposed RI requirements include the installation and sampling of monitoring wells at the 5T and 5U sites, and DSS of wells 01900035, 51902947, and 08000060. This OU could result in an increase in water supply of 10,500 gpm. The zone of nitrate contamination is in the vicinity of these new wells.

A.5.5.11 5A-J,L-MPQXY Main Objective: Contaminant Removal

All but one of the existing well clusters in Area 5 are included in this OU alternative. This OU provides the maximum removal of contamination possible using only existing wells. Cluster 5K is not included as recent sampling and has detected only low levels of contamination. Water supply could be increased by about 20,710 gpm. The RI needs required to implement this OU include DSS of wells 01900035, 08000060, and 51902947, and resampling of all wells for which recent analyses are not available. Nitrate contamination is present throughout much of this area.

A.5.5.12 5W Main Objective: Groundwater Resource

OU 5W consists of four new wells located between Area 6 and a pumping center in the southeastern portion of Area 5. The new wells would protect the pumping center from future migration of the contamination from Area 6. Although contamination has already been detected at the pumping center, much higher levels of contaminants upgradient of these wells are expected to migrate towards the pumping center. The new wells are proposed to depths of about 850 feet deep with individual capacities of about 2,500 gpm.

Potential RI needs for this alternative include DSS of well 98000108 to assess the current depth of contamination at the pumping center and additional data from site investigations regarding the vertical distribution of contaminants. Additional pumping in this area could have adverse effects on contaminant migration; however, computer modeling of groundwater flow and contaminant transport is necessary to assess the probability of these adverse effects occurring. An additional 10,000 gpm of capacity would be added to the water supply by implementation of OU 5W. Nitrates present a potential problem in this area.

A.5.6 AREA 6

Area 6 is a recharge area underlain by alternating layers of high and low permeability sediments. The bulk of the saturated alluvium in Area 6 appears to be contaminated above ALs and MCLs. The concentration of Site Assessment activities in this area has revealed concentrations of contaminants far in excess of those revealed in production wells both in Area 6 and throughout the rest of the basin. Concentrations of PCE have been measured at or near the solubility of PCE in water. The lack of wells in the northwestern part of this area leaves the downgradient extent very poorly defined. The zone of contamination may connect to the pumping center in southeastern Area 5 and may reach Area 4 via either a surface or subsurface pathway along San Jose Creek. However, Area 6 data are mostly from shallow wells; and few data are available at depth. There is some indication that contamination, especially PCE, decreases with depth. All six of the commonly occurring VOCs have been detected in Area 6. PCE concentrations are the highest (mean concentration greater than 170,000 ug/l), but TCE has been detected at levels greater than 2,800 ug/l, as well as DCE at 3,399 ug/l and TCA at over 8,200 ug/l.

All five existing production wells in Area 6 have been removed from service because of VOC contamination. Site investigation activities have located many potential source areas within Area 6, which is largely an industrial area. There is an especially high concentration of potential sources in the north-central portion of the area (City of Industry). The known zones of contamination greater than 50 ug/l in the area have been delineated based on ongoing site investigations.

There are seven well clusters in Area 6, five consist of new wells and two are existing well clusters. Table A-1 summarizes some of the characteristics of these well clusters. There are four proposed OU alternatives in Area 6 (Figure A-6). Two of the proposed OUs involve new well clusters, one consists of existing wells, and one would remediate contamination in San Jose Creek.

A.5.6.1 6AB Main Objective: Water Supply

Clusters 6A and 6B contain all five of the existing wells in Area 6. The wells have all been out of service for some time. This OU would return over 3,150 gpm to service (the capacity of well 019001617 is unknown). As indicated in Table A-1, three of the five wells are presently inoperable. If these wells are returned to service, the OU would include 6A wells only; and the increased water supply would be reduced to 2,535 gpm.

If all five wells are returned to service, this OU would provide some degree of migration control from the upper reaches of the Puente Valley where some of the highest contaminant levels are found. The RI needs associated with this OU include sampling of wells in 6A and 6B that have not been sampled in several years.

A.5.6.2 6CDFG Main Objective: Contaminant Removal

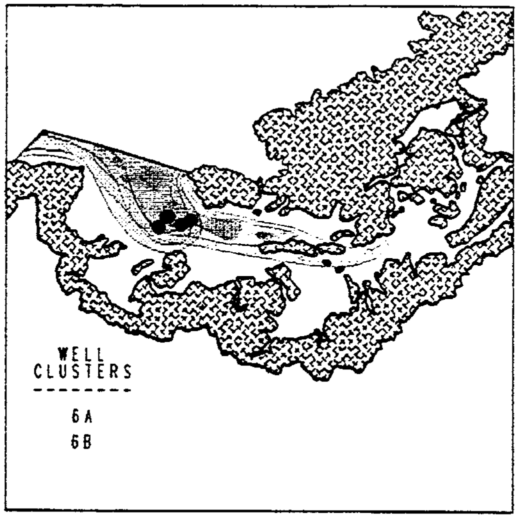
OU 6CDFG consists of four new well clusters with five new wells. The new wells are all located just downgradient of areas in which contamination exceeds 50 ug/l. Contamination is anticipated to occur throughout the depth of the aquifer in most of this area. Additional data from ongoing site investigation activities regarding the lateral and vertical distribution of contamination are required prior to implementation of this RI alternative. The new wells would range between 100 and 800 feet in depth and produce about 400 to 2,000 gpm. Based on these estimated capacities, an additional capacity of 7,400 gpm could become available.

Continued migration from the greater-than-50 ug/l areas would be inhibited by this OU. The known extent and number of such areas may increase as site investigation activities continue. This would probably necessitate a change in the scope of this OU to account for the increased area of contamination.

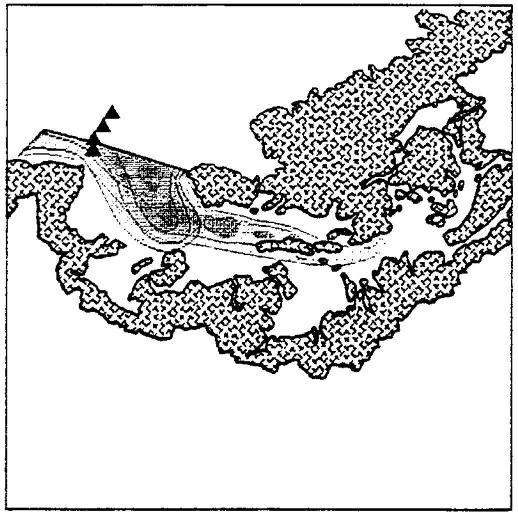
A.5.6.3 6E Main Objective: Manage Contaminant Migration

OU 6E consists of four new wells located in Areas 5 and 6 immediately downgradient of the large area of contamination originating in Area 6. This OU would manage further contaminant migration towards Area 4 and the production wells in the western portion of Area 5. The new well located furthest south is proposed as an RI monitoring well that could potentially be converted to an extraction well if considered feasible. Based on available data, the new wells would range from 400 to 900 feet deep and produce from about 1,500 to 2,500 gpm. An additional water supply of about 9,000 gpm could be created by this alternative.

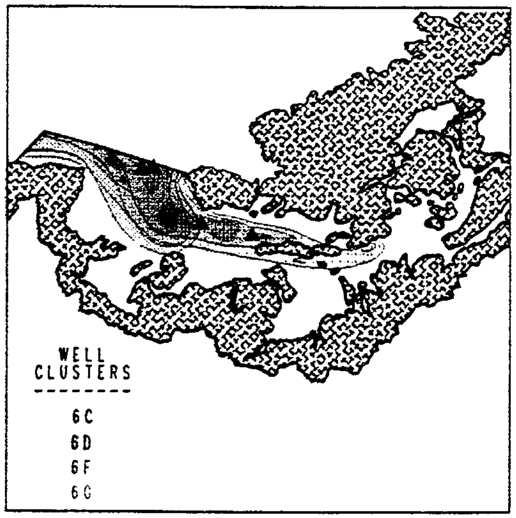
There are significant RI needs associated with this OU. The downgradient extent of the contaminated area near Area 4 is not well defined. Therefore, installation and sampling of the 6E RI monitoring well and another RI monitoring well downgradient near Area 4 are proposed. The DSS (at well 98000108 located in the southeast Area 5 pumping center) is also proposed to assess the depth and vertical distribution of contaminants. If the Area 6 contamination is continuous with the contaminated zones in Areas 4 or 5, then migration control



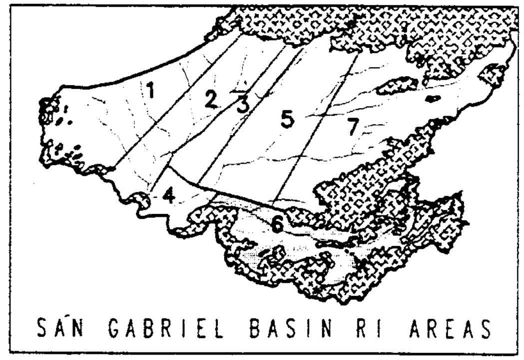
OU 6AB

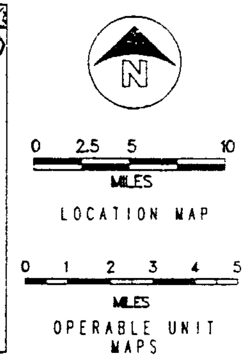


OU 6E



OU 6CDFG





LEGEND

- EXISTING WELL
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- RI AREA BOUNDARY
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- HYDROLOGIC BOUNDARY
- ALLUVIAL BASIN BOUNDARY
- VOC CONTAMINATION POTENTIALLY EXCEEDING 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM MCLs TO 10X MCLs
- VOC CONTAMINATION POTENTIALLY RANGING FROM LABORATORY DETECTION LIMITS TO MCLs
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 90 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 45 PPM
- NO3 CONTAMINATION POTENTIALLY EXCEEDING 20 PPM
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NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-6

AREA 6 OPERABLE UNITS

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at this location may not be practical. The detection of nitrate in this cluster is expected because of the proximity of an area of known nitrate contamination.

A.5.6.4 San Jose Creek Surface Water Main Objective: Prevent Exposure

The San Jose Creek drainage in Area 6 could be designated as an OU to address the contamination detected in the San Jose Creek and its gravel subdrain system. Implementation of surface water remedial actions could protect the public by minimizing the potential for contact with the contaminated water. Additionally, these actions could retard or block a relatively rapid migration pathway and remove contaminants from the system.

Little data are currently available regarding the nature of contamination, surface water-groundwater interactions, or the physical characteristics of the improved portions of the stream channel. Therefore, it is likely that significant additional RI activities would be required prior to initiation of a focused operable unit feasiblity study (OUFS), thereby increasing the time and cost relative to other remedial actions. Surface water actions, by themselves, would also do little to address the other remedial objectives.

A.5.7 AREA 7

Area 7 is largely a recharge area underlain by alternating high and low permeability layers. Known VOC contamination in the area is limited to one fairly small zone above ALs/MCLs. A large zone in which nitrate levels are greater than 45 mg/l covers most of the area.

Only two well clusters have been identified in Area 7, one with existing wells and one with a new well. Table A-1 lists some of the characteristics of the well clusters. Neither well in the existing well cluster has been shut down because of contamination. No potential sources have been identified in the VOC contaminated area, and there are no major industrial areas nearby.

Two potential OUs are proposed in Area 7 (Figure A-7). The following paragraphs describe these alternatives.

A.5.7.1 7A Main Objective: Contaminant Removal

OU 7A consists of two existing wells. The two wells in Cluster 7A are the only wells in Area 7 with contamination above ALs/MCLs. Neither of the wells has been removed from service because of the contamination. Continuously pumping the wells at capacity would maximize contaminant removal. Wellhead treatment would be implemented if necessary. Nitrates are the major groundwater contaminant in this area.

A.5.7.2 7B Main Objective: Manage Contaminant Migration

OU 7B consists of one new well located just downgradient of the VOC contaminated area. The contamination is assumed to occur at the base of the aquifer, at about 300 feet. This well would control migration of the contamination to currently clean areas. The new well would be 300 feet deep with a capacity of about 750 gpm. The RI data need would require additional information on the extent of the contaminated zone before implementation of this alternative. Nitrates would most likely be present in the new well.

A.6.0 EVALUATION OF OPERABLE UNIT DATA

The effectiveness of each OU is evaluated in a general, comparative fashion with respect to the remedial objectives outlined in Section 4.0. The remedial objectives are the following: prevent exposure, maintain adequate water supply, protect natural resources, manage contaminant migration, and contaminant removal. Data used to evaluate the remedial objectives are presented below.

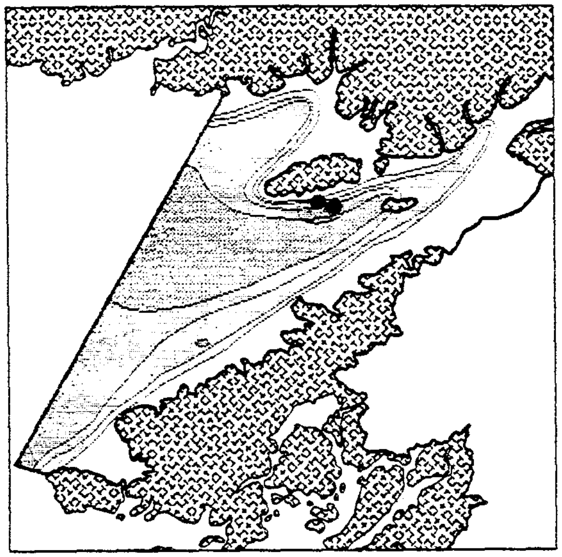
A.6.1 EVALUATION CRITERIA

The following sections describe the criteria used to evaluate each OU.

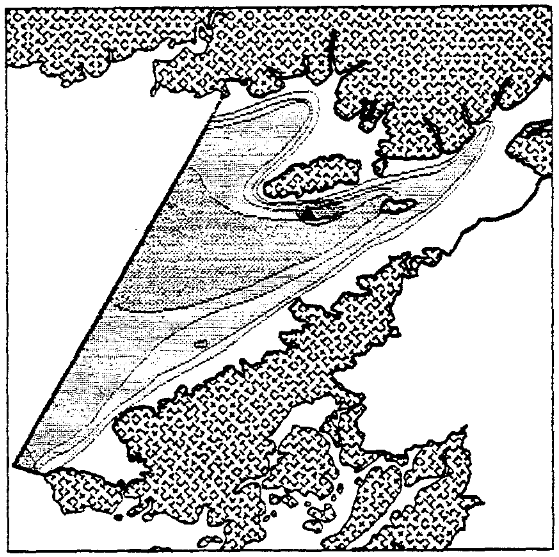
A.6.1.1 Cancer Risk Assessment

The exposure prevention objective is evaluated in terms of the excess lifetime cancer risk factors for each alternative. This screening level risk evaluation is used to address relative risk factors presented by individual well clusters. This evaluation should not be considered a risk assessment because it does not address potential exposure populations, their activities, and impacts; nor does this assessment consider the impacts of other chemical exposures. This evaluation is limited to the maximum reported and mean concentrations of carbon tetrachloride, 1,2-dichloroethane (DCA), 1,1,3-dichloroethylene (DCE), tetrachloroethylene (PCE), 1,1,1-trichloroethane (TCA), and trichloroethylene (TCE) detected in the wells within each well group. The general time period of sampling was 1984 to 1988 with some well samples taken as early as 1980.

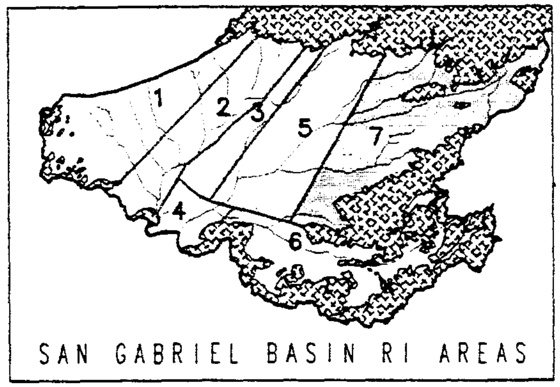
The evaluation uses EPA cancer potencies shown in Table A-5. Cancer potencies are upper boundary estimates (95 and 96 percentile) of the dose response function and therefore are unlikely to underestimate risks. 1,1,1-Trichloroethane is not included in the analysis because EPA has labelled it a category C carcinogen. Because DCE is currently considered a category C carcinogen, the analysis is done with and without DCE.

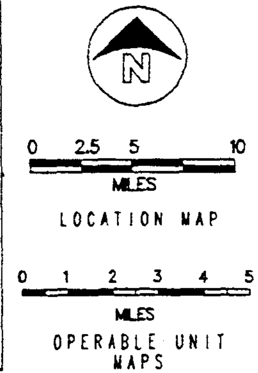


OU 7A



OU 7B





LEGEND

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NO3 NOTE: SOURCE - STETSON ENGINEERS

FIGURE A-7

AREA 7 OPERABLE UNITS

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Table A-5
CANCER POTENCIES AND EPA's WEIGHT OF EVIDENCE

Chemical	EPA Weight of Evidence	Cancer Potency (kg-day/mg)	Reference
Carbon tetrachloride	B2	0.13	IRIS (3/1/88)
1,2-Dichloroethane	B2	0.091	IRIS (3/1/88)
1,1-Dichloroethylene	C	0.60	IRIS (3/1/88)
Tetrachloroethylene (1)	B2	0.051	EPA (1986)
1,1,1-Trichloroethane	D		IRIS (9/7/88)
Trichloroethylene	B2	0.011	IRIS (3/1/88)

(1) Latest IRIS report states that tetrachloroethylene is under review for cancer potency, and no values are provided. Although older, the cited reference was used for a cancer potency in the absence of any current EPA judgment.

EPA WEIGHTS OF EVIDENCE

A. Human carcinogen. Sufficient evidence from epidemiologic studies to support a causal association between exposure and cancer.

B1. Probable human carcinogen. Limited evidence of carcinogenicity in humans from epidemiologic studies.

B2. Probable human carcinogen. Sufficient evidence of carcinogenicity in animals; inadequate evidence of carcinogenicity in humans.

C. Possible human carcinogen. Limited evidence of carcinogenicity in animals.

D. Not classified. Inadequate evidence of carcinogenicity in animals.

The risk evaluation assumes that an individual weighing 70 kg consumes 2 liters of contaminated water per day for 70 years. Risk, R, is calculated with the formula:

$$R = 1 - e^{-q^* \times I \times C/B}$$

where:
q^* = Cancer potency (kg - day/mg)
I = Water intake rate (l/day) = 2 l/day
C = Concentration (mg/l)
B = Body weight (kg) = 70 kg

It is also assumed that risk was additive across chemicals.

The excess lifetime cancer risks for each of the well groups is presented in Table A-6. An excess lifetime cancer risk of 1×10^{-6} can be interpreted as one additional cancer occurrence in a population of one million exposed over a lifetime. The potential impacts are calculated for an individual and not the entire basin population. The risk evaluation may be used as a tool to determine a measure of the potential relative risks among several well groups, but not to predict actual cancer occurrences in the San Gabriel Basin.

A.6.1.2 Water Supply

The water supply objective is evaluated by determining the impact each alternative has on the amount of water produced and whether or not any wells that are out of service as a result of contamination are returned to service. Table A-7 displays the net change in water supply and the number of contaminated wells returned to service.

The net change in water supply represents the added increase of production from new wells to production from all wells returned to active service (contaminated and otherwise), less the loss of production from any well clusters that are potentially shut down as part of the alternative. The number of contaminated wells returned to service reflects the total number of wells in the OU that are designated as shut down due to VOC or nitrate contamination of the well (Table A-1).

A.6.1.3 Contaminant Migration

The contaminant migration objective is evaluated by estimating the percent of lateral capture within the contaminated area and comparing the position of the cluster wells to the boundaries of the contaminated zone. The percent lateral contaminant capture represents a numerical semianalytical computer model (Javandel, et. al., 1984) in which the approximate width of the capture zones compares these wells to other wells with similar characteristics. The estimated lateral percentage of contaminant capture is displayed in Table A-7.

A.6.1.4 Contaminant Removal

The contaminant removal objective is evaluated by determining the total annual pounds of VOCs removed for each OU and the VOCs removed per million gallons of water produced. The values of mass of VOCs removed foreach OU are the sum of the individual values for each well included in the OU. The values are presented in Table A-7. The description of the derivation for each individual well value is presented in Section A.2.0.

A.6.2 COST AND COST RECOVERY CONSIDERATIONS

The relative cost of each OU is assessed with respect to the following cost factors: treatment size, well construction, additional RI data needs, the presence

Table A-6 (1 of 4)
SUMMARY COMPARISON OF POTENTIAL CANCER RISK FACTORS

		Excess Lifetime Cancer Risk			
		With 1,1-DCE		Without 1,1-DCE	
Cluster	Well No.	Maximum Reported Conc.	Mean Conc.	Maximum Reported Conc.	Mean Conc.
1A	01902786	8E-5	3E-5	1E-5	7E-6
1B	01900018	6E-6	2E-6	6E-6	2E-6
1C	01900013	3E-5	6E-6	7E-6	2E-6
	01900012	4E-6	2E-6	4E-6	2E-6
	Average	2E-5	4E-6	6E-6	2E-6
1E	01903097	5E-6	2E-6	5E-6	2E-6
	01901681	3E-5	2E-5	3E-5	2E-5
	Average	3E-5	2E-5	3E-5	2E-5
2A	01902030	1E-5	4E-6	1E-5	4E-6
	01902461	6E-6	2E-6	6E-6	2E-6
	Average	9E-6	3E-6	9E-6	3E-6
2B	01902018	5E-4	4E-4	1E-4	6E-5
	01902017	1E-4	6E-5	1E-4	6E-5
	01900418	2E-4	4E-5	7E-5	2E-5
	01900419	2E-5	2E-6	2E-5	2E-6
	01900356	3E-5	1E-5	7E-6	3E-6
	Average	8E-5	3E-5	4E-5	1E-5
2C	01902019	9E-5	2E-5	6E-5	2E-5
	01900420	2E-5	4E-7	2E-5	4E-7
	01900417	2E-5	4E-6	2E-5	4E-6
	01901013	2E-4	4E-5	5E-5	1E-5
	01901014	2E-4	3E-5	6E-5	7E-6
	Average	9E-5	2E-5	4E-5	7E-6
2D	01902948	1E-5	5E-6	1E-5	5E-6
	01902034	2E-5	7E-6	8E-6	4E-6
	Average	2E-5	6E-6	9E-6	5E-6
2E	21900749	1E-5	5E-6	1E-5	5E-6
	28000065	2E-5	4E-6	7E-6	3E-6
	21902857	9E-6	3E-6	9E-6	3E-6
	01902027	2E-5	8E-6	2E-5	8E-6
	Average	2E-5	5E-6	1E-5	4E-6
2F	01902031	8E-5	6E-5	7E-5	5E-5
	01902032	6E-5	3E-5	6E-5	3E-5
	01901695	3E-5	9E-6	3E-5	9E-6
	01902020	5E-6	9E-7	5E-6	9E-7
	Average	4E-5	2E-5	3E-5	2E-5
2G	01902787	4E-6	2E-6	4E-6	2E-6

Table A-6 (2 of 4)
(continued)

Cluster	Well No.	Excess Lifetime Cancer Risk: With 1,1-DCE: Maximum Reported Conc.	With 1,1-DCE: Mean Conc.	Without 1,1-DCE: Maximum Reported Conc.	Without 1,1-DCE: Mean Conc.
2H	01901055	5E-5	2E-5	5E-5	2E-5
2I	01902666	8E-6	3E-6	4E-6	2E-6
2M	01900458	3E-6	8E-7	3E-6	8E-7
2N	01902018	5E-4	4E-4	1E-4	6E-5
	01902017	1E-4	6E-5	1E-4	6E-5
	01902019	9E-5	2E-5	6E-5	1E-5
	Average	1E-4	6E-5	8E-5	3E-5
3A	01901178	1E-4	3E-5	1E-4	3E-5
	01902806	3E-4	1E-4	3E-4	1E-4
	Average	2E-4	8E-5	2E-4	8E-5
3B	11900729	7E-5	2E-5	7E-5	2E-5
3C	01901522	1E-4	5E-5	1E-4	5E-5
	01901521	1E-4	5E-5	1E-4	5E-5
	Average	1E-4	5E-5	1E-4	5E-5
3D	01901694	4E-5	2E-5	4E-5	2E-5
3E	01900120	2E-5	6E-6	2E-5	6E-6
	01900121	8E-5	2E-5	8E-5	2E-5
	Average	5E-5	1E-5	5E-5	1E-5
3G	01901692	1E-5	4E-6	1E-5	4E-6
4A	01902529	3E-4	2E-4	3E-4	2E-4
4B	08000049	7E-5	3E-5	5E-5	2E-5
4C	01900001	4E-5	1E-5	3E-5	1E-5
4D	11900095	5E-5	2E-5	2E-5	9E-6
	01902790	4E-5	3E-5	1E-5	7E-6
	Average	5E-5	2E-5	2E-5	8E-6
4E	81902525	1E-4	6E-5	5E-5	2E-5
	81902635	4E-5	2E-5	2E-5	5E-6
	Average	9E-5	4E-5	4E-5	2E-5
4F	01901433	5E-5	1E-5	2E-5	4E-6
	01900052	5E-5	2E-5	2E-5	7E-6
	Average	5E-5	2E-5	2E-5	5E-6
4G	41900745	1E-5	3E-6	1E-5	3E-6

Table A-6 (3 of 4)
(continued)

Cluster	Well No.	Excess Lifetime Cancer Risk — With 1,1-DCE — Maximum Reported Conc.	With 1,1-DCE — Mean Conc.	Without 1,1-DCE — Maximum Reported Conc.	Without 1,1-DCE — Mean Conc.
5A	01902537	3E-4	2E-5	2E-4	2E-5
	01900831	8E-3	3E-3	2E-4	6E-5
	11900038	7E-3	2E-3	1E-3	7E-4
	Average	4E-3	2E-3	5E-4	2E-4
5B	01900029	7E-4	3E-4	5E-4	2E-4
	01900117	2E-4	1E-4	2E-4	1E-4
	Average	5E-4	2E-4	3E-4	2E-4
5C	01900034	7E-4	1E-4	7E-4	1E-4
	08000060	3E-3	1E-3	1E-3	3E-4
	01902169	2E-4	1E-4	7E-5	4E-5
	Average	2E-3	6E-4	9E-4	2E-4
5D	01900882	1E-4	9E-5	1E-4	7E-5
	01900883	7E-5	5E-5	7E-5	5E-5
	01900885	8E-5	4E-5	8E-5	4E-5
	Average	1E-4	6E-5	9E-5	5E-5
5F	08000039	2E-4	1E-4	2E-4	1E-4
5G	01900035	1E-4	8E-5	1E-4	6E-5
5H	01901598	2E-5	6E-6	2E-5	6E-6
	01901599	3E-5	6E-6	3E-5	6E-6
	Average	3E-5	6E-6	3E-5	6E-6
5I	01900031	2E-4	7E-5	1E-4	4E-5
	71903093	1E-4	4E-5	1E-4	4E-5
	71900721	2E-4	5E-5	1E-4	4E-5
	Average	2E-4	6E-5	1E-4	4E-5
5J	51902858	8E-5	2E-5	8E-5	2E-5
	51902947	1E-4	3E-5	1E-4	3E-5
	Average	9E-5	3E-5	9E-5	3E-5
5K	08000093	5E-6	3E-6	5E-6	3E-6
	01903067	1E-5	3E-6	1E-5	3E-6
	Average	1E-5	3E-6	1E-5	3E-6
5L	01902951	3E-4	2E-4	2E-4	2E-4
5M	91901439	5E-5	8E-6	2E-5	4E-6
	Z1901439	3E-4	8E-5	2E-5	4E-6
	91901440	3E-5	5E-6	2E-5	3E-6
	98000068	8E-5	3E-5	4E-5	1E-5
	Average	1E-4	3E-5	3E-5	6E-6

Table A-6 (4 of 4)
(continued)

		Excess Lifetime Cancer Risk			
		With 1,1-DCE		Without 1,1-DCE	
Cluster	Well No.	Maximum Reported Conc.	Mean Conc.	Maximum Reported Conc.	Mean Conc.
5N	91901437	1E-4	4E-5	6E-5	2E-5
	01900337	3E-5	5E-6	2E-5	3E-6
	01901596	1E-5	6E-6	9E-6	4E-6
	Average	5E-5	2E-5	3E-5	9E-6
5P	01901627	3E-5	7E-6	2E-5	6E-6
5Q	01902117	1E-5	6E-6	1E-5	6E-6
5X	01902581	1E-4	5E-5	4E-5	1E-5
	01902582	2E-4	1E-4	4E-5	2E-5
	Average	2E-4	9E-5	4E-5	2E-5
6A	31902820	4E-4	2E-4	2E-4	9E-5
	31902819	7E-4	4E-4	4E-4	2E-4
	01901617	6E-5	5E-5	6E-5	5E-5
	Average	4E-4	2E-4	2E-4	1E-4
6B	01901621	4E-4	2E-4	4E-4	2E-4
	01901625	5E-4	2E-4	5E-4	2E-4
	Average	5E-4	2E-4	5E-4	2E-4
7A	01902270	2E-5	6E-6	2E-5	6E-6
	01902271	5E-5	2E-5	4E-5	1E-5
	Average	4E-5	2E-5	3E-5	1E-5

Notes: Calculated risks assume an individual weighing 70 kg ingesting 2 liters of water per day for a lifetime. These calculated risks are considered to be hypothetical, as no known human population is exposed at this level.

An "0" in the chemical concentrations was assumed to be zero.

An "ND" in the chemical concentrations was assumed to be unavailable, and no concentrations were used.

Estimated concentrations in proposed wells were not included.

Table A-7
Operable Unit Alternatives
Evaluation Backup Table

Operable Unit Alternative	Net Change in Water Supply (gpm)	# of Contaminated Wells Returned to Service	Estimated Lateral % of Contaminant Zone Captured	VOCs Removed Per Million Gallons (lbs)	Total Annual VOCs Removed (lbs)
OU1E	+ 1250	1	90	0.14	100
OU1D	+ 1500	0	95	0.21	84
OU1ABCE	+ 1740	2	95	0.36	205
OU2BCFH	- 1570	7	100	6.61	3143
OU2FH	+ 1090	3	90	1.59	362
OU2N	+ 4110	3	50	4.03	1474
OU2BCFK	+ 780	7	75	6.90	4150
OU2J	+ 9000	0	100	1.08	1683
OU2LM	+ 2000	0	85	10.82	2844
OU2A-I,M	+ 7120	8	88	7.34	3575
OU3D	+ 1330	1	70	0.10	70
OU3BD	+ 1330	1	100	0.20	157
OU3F	+ 3000	0	100	0.30	392
OU3BDEG	+ 1330	1	100	0.41	283
OU4E	+ 3660	2	100	0.27	325
OU4K	+ 6250	0	100	0.60	647
OU4IJ	+ 3000	0	60	3.39	1334
OU4I	+ 1500	0	90	1.46	574
OU4H5R	+ 2250	0	30	3.37	1985
OU4A-G	+ 3660	2	65	1.97	718
OU5MN	0	0	35	0.29	270
OU5P	0	0	100	0.04	40
OU5W	+10000	0	50	0.52	658
OU5CDI	+13070	5	70	10.03	16622
OU5CDG	+14890	5	70	9.76	16720
OU5L	0	0	45	1.20	158
OU5IJ	+ 1880	1	45	0.95	1185
OU5S	+10500	0	65	0.48	857
OU5FGHT	+ 7950	2	85	1.40	2307
OU5TUV	+10500	0	50	9.88	18197
OU5DGTUV	+21790	4	65	13.61	23498
OU5A-J,L-N,PQXY	+20710	9	100	36.46	39760
OU6AB	+ 3150	5	75	5.07	1716
OU6E	+ 9000	0	90	0.52	593
OU6CDFG	+ 7400	0	60	16.36	11952
SAN JOSE CREEK	0	0	0	-	-
OU7A	0	0	75	0.15	39
OU7B	+ 750	0	100	0.11	42

of other contaminants, and the potential for cost recovery. The data used in the evaluation of the cost factors are presented in Table A-8.

A.6.2.1 Treatment Size

The treatment size factor is evaluated by determining the total potential treatment requirements for each OU. The number of wells to be treated and the potential flow rate of the water to be treated are presented in Table A-8. The number of wells requiring treatment is the sum of the wells to be treated within each OU. The potential total gpm of treatment required is the sum of the capacities of all the wells that may be treated. The capacities of individual wells are shown in Table A-1.

A.6.2.2 Well Construction

The well construction factor considers whether new wells are proposed as part of the alternative and evaluates the distance from the new well cluster to a 12-inch or greater water distribution line. The number of proposed new wells for each OU, the total footage to be drilled in each OU, and the distance of the new cluster from a 12-inch or greater distribution line are presented in Table A-8.

The total drilled footage is the sum of the estimated depth of all proposed new wells within an OU. The distance from each new well to a 12-inch or greater distribution line is measured and listed in Table A-8.

A.6.2.3 Cost Recovery

The cost recovery factor is evaluated by determining the distance of each OU from areas containing potential upgradient sources. The potential sources are defined as industrial areas or source investigation sites for the purpose of this evaluation. The closest distance from each well to a potential upgradient site or industrial area with potential sources is measured and tabulated in Table A-8. Where the distance is listed as zero, the OU is located within an industrial area. The distances listed in Table A-8 are presented for comparative purposes at a conceptual level; these numbers are not considered accurate or representative of the actual distance travelled by contaminants from a specific source.

A.6.2.4 Additional RI Data Needs

The additional RI data needs factor assigns a qualifier to the amount of additional RI proposed for each well cluster. The four qualifiers are "none," "limited," "moderate," and "extensive." A brief summary of the proposed additional RI data needs along with the accompanying qualifier is presented in Table A-8.

Table A-8
Operable Unit Alternatives
Cost Backup Table

Operable Unit Alternative	Treatment # of wells	Treatment flow rate (gpm)	New Wells No.	New Wells Total Drilled Footage (ft)	New Wells Distance to 12" Pipeline (ft)	Upgradient Dist. to Potential Sources (ft)	Additional Remedial Investigation Data Requirements
OU1E	2	2930	-	-	-	0	DSS- 2 wells (lim.)
OU1D	2	1500	2	800	1270	1060	DSS- 2 wells (lim.)
OU1ABCE	6	6560	-	-	-	0	DSS- 2 wells (lim.)
OU2BCFH	15	26220	-	-	-	0	DSS- 2 wells, additional sampling (lim.)
OU2FH	5	2480	-	-	-	0	DSS- 2 wells, additional sampling (lim.)
OU2H	3	4110	-	-	-	0	additional sampling (lim.)
OU2BCFK	15	28570	1	600	1800	0	DSS- 3 wells, 1 new MW, additional sampling (ext.)
OU2J	3	9000	3	2400	2010	1300	DSS- 1 well, 1 new MW, sampling of pilot hole (mod.)
OU2LM	5	2640	4	800	630	0	additional site investigation data (lim.)
OU2A-I,M	26	37780	-	-	-	0	DSS- 3 wells (mod.)
OU3D	1	1330	-	-	-	1060	additional sampling (lim.)
OU3BD	2	3130	-	-	-	1060	DSS- 2 wells, additional sampling (lim.)
OU3F	2	5000	2	1200	2110	2320	DSS- 2 wells, 1 new MW (mod.)
OU3BDEG	6	8260	-	-	-	840	DSS- 2 wells, additional sampling (lim.)
OU4E	2	3660	-	-	-	0	Corps MW data (lim.)
OU4K	3	6250	3	1600	950	0	1 new MW, and Corps MW data (mod.)
OU4IJ	4	3000	4	1000	4010	0	additional site investigation data (lim.)
OU4I	2	1500	2	500	4010	0	additional site investigation data (lim.)
OU4H5R	2	2250	2	700	1270	2640	1 new MW, and Corps MW data (mod.)
OU4A-G	10	11980	-	-	-	0	Corps MW data, existing MW data (lim.)
OU5MN	4	6540	-	-	-	0	DSS- 1 well (lim.)
OU5P	1	1900	-	-	-	0	additional sampling (lim.)
OU5W	4	10000	4	3400	840	0	DSS- 1 well, additional site investigation data, additional computer modeling (mod.)
OU5CDI	7	14310	-	-	-	0	DSS- 3 wells, 1 new MW, additional sampling (ext.)
OU5CDG	6	14890	-	-	-	0	additional sampling (lim.)
OU5L	1	250	-	-	-	530	additional sampling (lim.)
OU5IJ	4	9780	-	-	-	0	DSS- 3 wells, 1 new MW, additional sampling (ext.)
OU5S	3	10500	3	3000	1060	0	DSS- 3 wells, 2 new MW (ext.)
OU5FGHT	5	15120	1	1200	0	2110	DSS- 2 wells, 1 new MW, additional sampling (mod.)
OU5TUV	3	10500	3	3400	950	0	DSS- 3 wells, 2 new MW (ext.)
OU5DGTUV	7	21790	3	3400	950	0	DSS- 3 wells, 2 new MW, additional sampling (ext.)
OU5A-J,L-N,PQXY	34	73130	-	-	-	0	DSS- 3 wells, additional sampling (mod.)
OU6AB	5	3150	-	-	-	1160	additional sampling (lim.)
OU6E	4	9000	4	3000	2430	0	DSS- 1 wells, 2 new MW (ext.)
OU6CDFG	5	7400	5	2900	4220	0	additional site investigation data (lim.)
SAN JOSE CREEK	-	-	-	-	-	0	undetermined (ext.)
OU7A	2	919	-	-	-	3590	none
OU7B	1	750	1	300	840	6340	undetermined (lim.)

A qualifier of "none" indicates that no additional RI work is proposed for the alternative. The "limited" qualifier refers to depth-specific sampling of two wells or less. "Limited" is also used if additional data analysis from other investigations is necessary or if additional groundwater sampling is proposed. The "moderate" qualifier is used if a new RI monitoring well or DSS of three wells is proposed and for the alternative which requires additional computer modeling. The "extensive" qualifier is used if two new RI monitoring wells are proposed or if DSS of three wells and a new RI monitoring well is proposed.

A.6.3 SUMMARY

The various factors described in the preceding two sections are useful indicators of the potential cost-effectiveness of particular remedial actions. As a summary of these factors, two tables are presented in which (1) considerations pertaining to the ability of the individual remedial actions (OUs) to satisfy the remedial objectives (Table A-9), and (2) issues related to the potential cost of each OU (Table A-10), have been tabulated for comparative purposes.

TABLE A-9

COMPARISON OF OPERABLE UNITS BY ABILITY TO SATISFY OBJECTIVES (1 OF 3)

	PREVENT EXPOSURE			WATER SUPPLY			GROUNDWATER RESOURSE		MANAGE CONTAMINANT MIGRATION					CONTAMINANT REMOVAL						SOURCE CONTROL		
	EXCESS CANCER RISK FACTOR			IMPACT ON AMOUNT OF WATER PRODUCED			IMPACT ON RESOURCE		PERCENT LATERAL CAPTURE			POSITION		TOTAL ANNUAL VOC REMOVAL			VOC REMOVAL PER MILL. G			IMPACT ON ACTION		
OPERABLE UNIT ALTERNATIVE	10 -6	10 -5	10 -4	Increase	Decrease	Allows use of Out-of-Service Wells	Protects Down-gradient Wells from Potential Future Contamination	Minimizes Intrabasin Migration	> 90 %	60 - 90 %	< 60 %	At or Near Inferred Downgradient Boundary	Not Near Boundary Or Boundary Poorly Known	> 5,000 lbs	500 - 5,000 lbs	< 500 lbs	> 5 lbs	1 - 5 lbs	< 1 lb	Does not Mitigate Known Sourse Area	Mitigates Potentially Significant Source	Mitigates Source (size unknown)
1E		●		●		●	●	●		●			●			●			●	●		
1D		◌		●			●	●	●				●			●			●	●		
1ABCE			●	●		●	●	●	●				●			●			●	●		
2BCFH		●			●	●			●				●		●		●			●		
2FH		●		●		●				●			●			●		●		●		
2N		●		●		●					●		●		●			●		●		
2BCFK		◌		●		●				●			●		●		●			●		
2J	UNKNOWN			●			●	●	●			●			●			●		●		
2LM	◌			●			●	●		●		●			●		●					●
2A-I,M			●	●		●				●			●		●		●			●		
3D		●		●		●	●	●		●			●			●			●	●		
3BD		●		●		●	●	●	●				●			●			●	●		
3F	UNKNOWN			●			●	●	●				●			●			●	●		
3BDEG		●		●		●	●	●	●				●			●			●	●		

Note: Excess Cancer Risk was not estimated for operable units consisting entirely of new wells.
Cancer Risk factors for operable units consisting of both existing and new wells are designated with a ◌.

TABLE A-9

COMPARISON OF OPERABLE UNITS BY ABILITY TO SATISFY OBJECTIVES (2 OF 3)

	PREVENT EXPOSURE			WATER SUPPLY			GROUNDWATER RESOURSE		MANAGE CONTAMINANT MIGRATION					CONTAMINANT REMOVAL						SOURCE CONTROL		
	EXCESS CANCER RISK FACTOR			IMPACT ON AMOUNT OF WATER PRODUCED			IMPACT ON RESOURCE		PERCENT LATERAL CAPTURE			POSITION		TOTAL ANNUAL VOC REMOVAL			VOC REMOVAL PER MILL. G			IMPACT ON ACTION		
OPERABLE UNIT ALTERNATIVE	10 -6	10 -5	10 -4	Increase	Decrease	Allows use of Out-of-Service Wells	Protects Down-gradient Wells from Potential Future Contamination	Minimizes Intrabasin Migration	> 90 %	60 - 90 %	< 60 %	At or Near Inferred Downgradient Boundary	Not Near Boundary Or Boundary Poorly Known	> 5,000 lbs	500 - 5,000 lbs	< 500 lbs	> 5 lbs	1 - 5 lbs	< 1 lb	Does not Mitigate Known Sourse Area	Mitigates Potentially Significant Source	Mitigates Source (size unknown)
4E		●		●		●			●				●			●			●	●		
4K	UNKNOWN			●				●	●			●			●				●	●		
4IJ	UNKNOWN			●			●	●		●		●			●			●				●
4I	UNKNOWN			●			●	●		●		●			●			●				●
4H5R	UNKNOWN			●							●		●		●			●		●		
4A-G			●	●		●				●			●		●			●		●		
5MN		●									●		●			●			●	●		
5P	●							●	●			●				●			●	●		
5W	UNKNOWN			●			●				●		●		●				●	●		
5CDI			●	●		●				●			●	●			●			●		
5CDG			●	●		●				●			●	●			●			●		
5L			●								●		●			●		●		●		
5IJ		●		●		●		●			●		●		●				●	●		
5S	UNKNOWN			●				●		●			●		●				●	●		

Note: Excess Cancer Risk was not estimated for operable units consisting entirely of new wells.
Cancer Risk factors for operable units consisting of both existing and new wells are designated with a ( ).

TABLE A-9

COMPARISON OF OPERABLE UNITS BY ABILITY TO SATISFY OBJECTIVES (3 OF 3)

	PREVENT EXPOSURE			WATER SUPPLY			GROUNDWATER RESOURSE		MANAGE CONTAMINANT MIGRATION					CONTAMINANT REMOVAL						SOURCE CONTROL		
	EXCESS CANCER RISK FACTOR			IMPACT ON AMOUNT OF WATER PRODUCED			IMPACT ON RESOURCE		PERCENT LATERAL CAPTURE			POSITION		TOTAL ANNUAL VOC REMOVAL			VOC REMOVAL PER MILL. G			IMPACT ON ACTION		
OPERABLE UNIT ALTERNATIVE	10 -6	10 -5	10 -4	Increase	Decrease	Allows use of Out-of-Service Wells	Protects Down-gradient Wells from Potential Future Contamination	Minimizes Intrabasin Migration	> 90 %	60 - 90 %	< 60 %	At or Near Inferred Downgradient Boundary	Not Near Boundary Or Boundary Poorly Known	> 5,000 lbs	500 - 5,000 lbs	< 500 lbs	> 5 lbs	1 - 5 lbs	< 1 lb	Does not Mitigate Known Sourse Area	Mitigates Potentially Significant Source	Mitigates Source (size unknown)
5FGHT			◌	●		●		●		●			●		●			●		●		
5TUV	UNKNOWN			●							●		●	●			●			●		
5DGTUV			◌	●		●				●			●	●			●			●		
5A-J,L-NPQXY			●	●		●		●	●				●	●			●			●		
6AB			●	●		●				●			●	●				●		●		
6E	UNKNOWN			●				●		●		●			●				●	●		
6CDFG	UNKNOWN			●				●		●			●	●			●					●
6H	UNKNOWN			●				●	●				●	●			●			●		
SAN JOSE CR.	UNKNOWN							●			●		●							●		
7A		●								●			●			●			●	●		
7B	UNKNOWN			●			●	●	●			●				●			●	●		

Note: Excess Cancer Risk was not estimated for operable units consisting entirely of new wells.
Cancer Risk factors for operable units consisting of both existing and new wells are designated with a ◌.

F: \FIGURES\LA062440.TP\A9-3.DWG

TABLE A-10

COMPARISON OF OPERABLE UNITS BY ABILITY TO SATISFY OBJECTIVES (1 OF 3)

	COST														COST RECOVERY		
	TREATMENT SIZE			WELL CONSTRUCTION				ADDITIONAL RI DATA NEEDS				OTHER CONTAMINANTS > MCLs/ALS			DISTANCE FROM POTENTIAL UPGRADIENT SOURCES		
OPERABLE UNITS	> 10,000 GPM	4000 - 10,000 GPM	< 4000 GPM	No New Wells	New Wells Required	<1000 ft to 12in Line	>1000 ft to 12in Line	None	Limited	Moderate	Extensive	Potential Nitrates	Nitrates Present	Others	0 ft	0 - 1500 ft	> 1500 ft
1E			●	●					●				●		●		
1D			●		●		●		●				●			●	
1ABCE		●		●					●				●		●		
2BCFH	●			●					●				●		●		
2FH			●	●					●				●		●		
2N		●		●					●				●		●		
2BCFK	●				●		●				●		●		●		
2J		●			●		●			●						●	
2LM			●		●	●			●					●	●		
2A-I,M	●			●						●			●		●		
3D			●	●					●			●				●	
3BD			●	●					●			●				●	
3F		●			●		●			●		●					●
3BDEG		●		●					●				●			●	
4E			●	●					●						●		
4K		●			●	●				●					●		
4IJ			●		●		●		●					●	●		

TABLE A-10

COMPARISON OF OPERABLE UNITS BY ABILITY TO SATISFY OBJECTIVES (2 OF 3)

	COST														COST RECOVERY		
	TREATMENT SIZE			WELL CONSTRUCTION				ADDITIONAL RI DATA NEEDS				OTHER CONTAMINANTS > MCLs/ALS			DISTANCE FROM POTENTIAL UPGRADIENT SOURCES		
OPERABLE UNITS	> 10,000 GPM	4000 - 10,000 GPM	< 4000 GPM	No New Wells	New Wells Required	<1000 ft to 12in Line	>1000 ft to 12in Line	None	Limited	Moderate	Extensive	Potential Nitrates	Nitrates Present	Others	0 ft	0 - 1500 ft	> 1500 ft
4I			●		●		●		●					●	●		
4H5R			●		●		●			●		●					●
4A-G	●			●					●						●		
5MN		●		●					●			●			●		
5P			●	●					●						●		
5W		●			●	●				●		●			●		
5CDI	●			●							●	●			●		
5CDG	●			●					●			●			●		
5L			●	●					●			●				●	
5IJ		●		●							●	●			●		
5S	●				●		●				●		●		●		
5FGHT	●				●	●				●			●				●
5TUV	●				●	●					●	●		●	●		
5DGTUV	●				●	●					●	●		●	●		
5A-J,L-N, PQXY	●			●						●			●	●	●		

TABLE A-10

COMPARISON OF OPERABLE UNITS BY ABILITY TO SATISFY OBJECTIVES (3 OF 3)

	COST														COST RECOVERY		
	TREATMENT SIZE			WELL CONSTRUCTION				ADDITIONAL RI DATA NEEDS				OTHER CONTAMINANTS > MCLs/ALS			DISTANCE FROM POTENTIAL UPGRADIENT SOURCES		
OPERABLE UNITS	> 10,000 GPM	4000 - 10,000 GPM	< 4000 GPM	No New Wells	New Wells Required	<1000 ft to 12in Line	>1000 ft to 12in Line	None	Limited	Moderate	Extensive	Potential Nitrates	Nitrates Present	Others	0 ft	0 - 1500 ft	> 1500 ft
6AB			●	●					●							●	
6E		●			●		●				●		●		●		
6CDFG		●			●		●		●					●	●		
SAN JOSE CR.											●		●		●		
7A			●	●				●					●				●
7B			●		●	●			●				●				●

A.7.0 REFERENCES

Javandel, I., C. Doughty, and C. F. Tsang. Groundwater Transport: Handbook of Mathematical Models: No. 10, Water Resources Monograph Series. American Geophysical Union. Washington, D.C. 1984.

Appendix B
COST ESTIMATES -
SINGLE-OBJECTIVE APPROACH

APPENDIX B

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APPENDIX B

TABLES

FIGURES

Appendix B
COST ESTIMATES - SINGLE-OBJECTIVE APPROACH

B.1.0 INTRODUCTION

As described in Sections 1.0, 3.0, and 4.0 of Volume One of this plan, remediating groundwater contamination in the San Gabriel Basin may be considered within the context of either a single-objective or multiple-objective approach. The single-objective approach involves implementing remedial action(s) designed to address a single objective or set of objectives. This is generally analogous to typical Remedial Investigation (RI) and Feasibility Study (FS) efforts at many Superfund sites, particularly small sites. At a site as large and complex as the San Gabriel Basin, such an approach is difficult to implement, particularly because of the very large effort required to completely understand the natural system and adequately plan remedial actions. Instead, a multiple-objective approach may be pursued, in which early actions are implemented to address achievable objectives, and to help set the stage for subsequent actions that address more ambitious objectives. This is the approach followed in this technical plan.

Single-objective approaches, however, provide a valuable method of comparatively evaluating a variety of general techniques of remediation. It is convenient and illustrative to compare, for example, the potential cost of trying simply to provide a continuous supply of drinking water, with that of actively attempting to reduce the extent of groundwater contamination. Such an evaluation was performed early in this project (Tables 3-1 and 3-2). This appendix provides an updated evaluation of this type, using the extensive knowledge gained in recent years. The results presented in this appendix are summarized in Section 4.1.1 and Table 4-1.

In the following section, the three objectives selected for evaluation in this appendix are described. These descriptions are followed by a discussion of some of the assumptions followed in developing cost estimates for these objectives. Finally, the cost estimates themselves will be tabulated and described.

B.2.0 SINGLE-OBJECTIVE APPROACHES

Three general objectives have been selected for evaluation. As explained above, these represent three general, basinwide approaches to remediation that are useful to evaluate for comparative purposes; they do not represent the actual approaches to remediation recommended in this plan. Rather, approximate estimates of the cost of pursuing these objectives should help illustrate the viability of pursuing one type of action instead of another, and should underscore the greater implementability and cost effectiveness of a multiple-objective approach in the case of the San Gabriel Basin.

B.2.1 MAINTAIN AN ADEQUATE WATER SUPPLY

One of the most basic objectives of remediation efforts in the San Gabriel Basin is to ensure a continuous supply of drinking water to the approximately one million inhabitants. To date, this has been achieved by the water purveyors of the basin by moving and modifying wells to avoid contaminated water, and by blending contaminated water with cleaner water. Unfortunately, the relocation of production wells, as well as increased production from deeper portions of the aquifer, appears to have exacerbated the spread of groundwater contamination (Section 2.0). If treatment is provided at all wells within contaminated areas, the potentially deleterious effects of shutting down or modifying wells in contaminated areas can be avoided. However, simply providing treatment at contaminated wells as they become contaminated will do little to either prevent the continued spread of contamination, or to reduce the current extent of contamination. Eventually, treatment would be required at a majority of production wells within the basin.

To estimate an approximate cost for this type of approach, the numerical model described in Section 2.0 and in Appendix C has been used. Wells within the extent of contamination projected for the year 2009 have been identified, as shown in Figure B-1. The numerical calculations used by the model to produce future projections of the extent of contamination assume that pumping patterns for the next 20 years will follow the same pattern observed over the last 10 years. Thus, according to the numerical model, the extent of contamination shown in Figure B-1 approximates the future condition of the basin if no action, other than treatment at existing wells, is taken. In addition, it should be noted that these projections rely on very uncertain assumptions regarding the nature of continuing sources of contamination, not only at the surface, but within the aquifer as well.

B.2.2 CONTROL CONTAMINANT MIGRATION

More ambitious than simply continuing to provide drinking water within federal and state standards, is the objective of actively managing the spread of contamination to prevent losing those portions of the aquifer not yet contaminated. As defined herein, this objective includes maintaining an adequate water supply by providing treatment at wells within presently contaminated

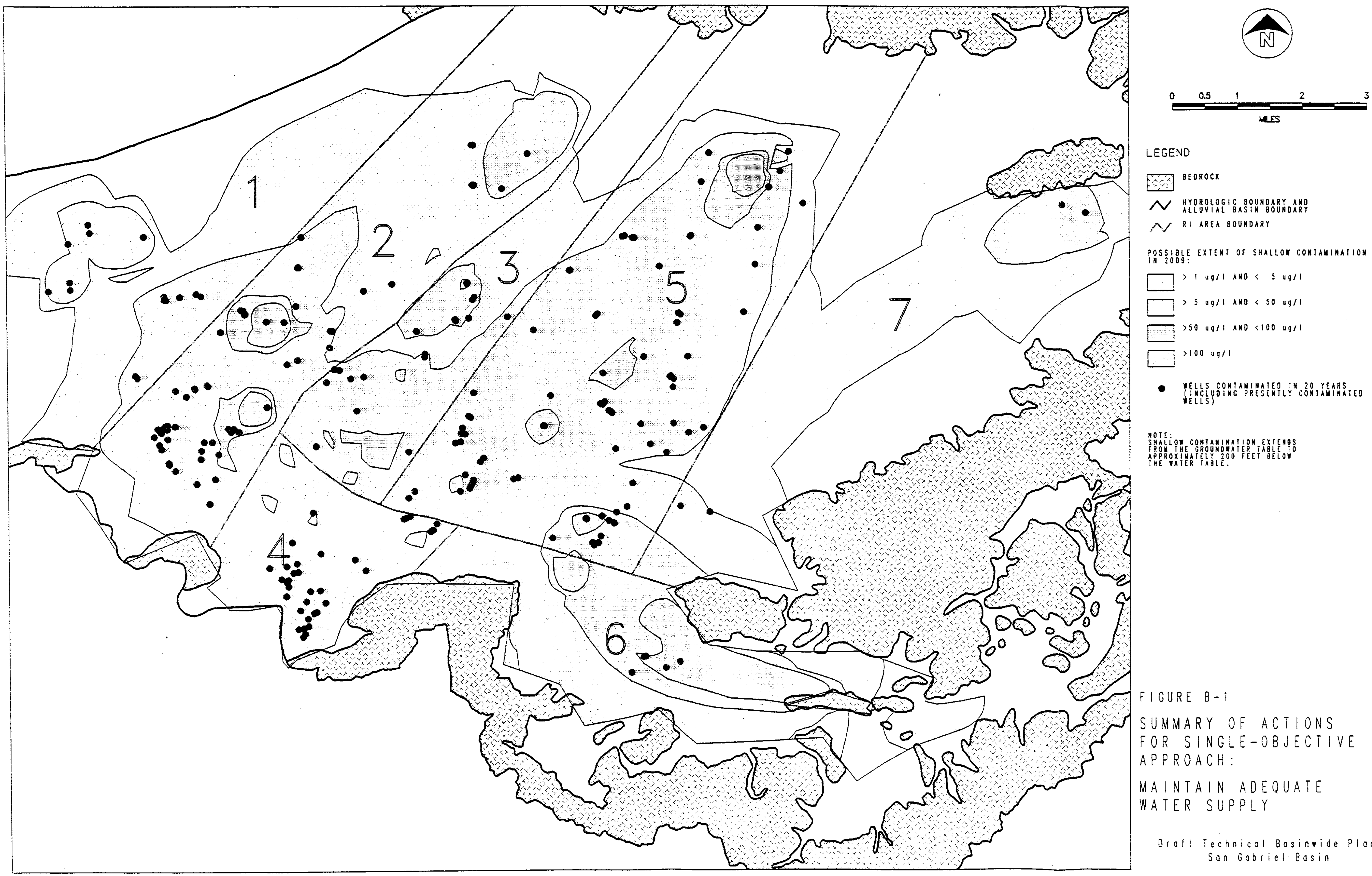

FIGURE B-1

SUMMARY OF ACTIONS FOR SINGLE-OBJECTIVE APPROACH:

MAINTAIN ADEQUATE WATER SUPPLY

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San Gabriel Basin

areas. In addition, operable units (OU) designed to prevent continued migration at the downgradient margins of presently contaminated areas would also be implemented, as shown in Figure B-2. Such an approach would also likely involve eliminating or reducing production at a majority of the wells presently operating within uncontaminated portions of the basin, because of the increase in available water from contaminated portions of the basin.

The implementation of such an approach would, if actually adopted, be severely limited by the present inability to accurately assess the potentially adverse effects that could result from an ill-designed action. As will be shown by the assessments of the effects of several of the potential operable units (described in Appendix A) on groundwater flow and contaminant transport presented in Appendix C, considerable care must be taken to avoid implementing actions that produce more harm than good. The effective design and placement of high-capacity extraction wells at downgradient margins of contamination require a relatively high degree of understanding of subsurface conditions. An inadequately designed system could potentially accelerate migration of contaminants throughout the region, as well as fail to curb continued migration across it. Nevertheless, for the purposes of the current assessment, it is assumed that sufficient knowledge is available to effectively implement most of the potential actions described in Appendix A as being designed to control contaminant migration.

B.2.3 REMOVE CONTAMINATION

The most ambitious approach evaluated in this appendix is the implementation of actions designed to remove the bulk of the volatile organic compound (VOC) contamination from the basin. To achieve this objective, it is envisioned that large operable units, consisting for the most part of existing wells, could be installed in all areas in which VOC contamination is currently known to exist at relatively high concentrations. The operable units selected to address this objective are shown in Figure B-3 and are described in Appendix A. Wells within these operable units would be generally pumped at capacity to maximize the rate of contaminant withdrawal and the degree of contaminant migration control. Existing wells might be modified to selectively pump from contaminated horizons within the aquifer. In some areas, these would be supplemented with new wells installed to extract from portions of the aquifer not affected by pumping at existing wells.

Considerable effort would also be required to achieve the level of knowledge necessary to implement a basinwide approach of this sort. Although some assessments of the regional consequences of implementing these types of remedial actions have been made (Section 5.0 and Appendix A), the combined effects of contemporaneous pumping at numerous operable units is more complex and difficult to assess accurately. Thus, as with the previous objective, the actual implementation of a basinwide approach of this type requires substantial investigation and evaluation to minimize the potential for inadvertently worsening conditions.

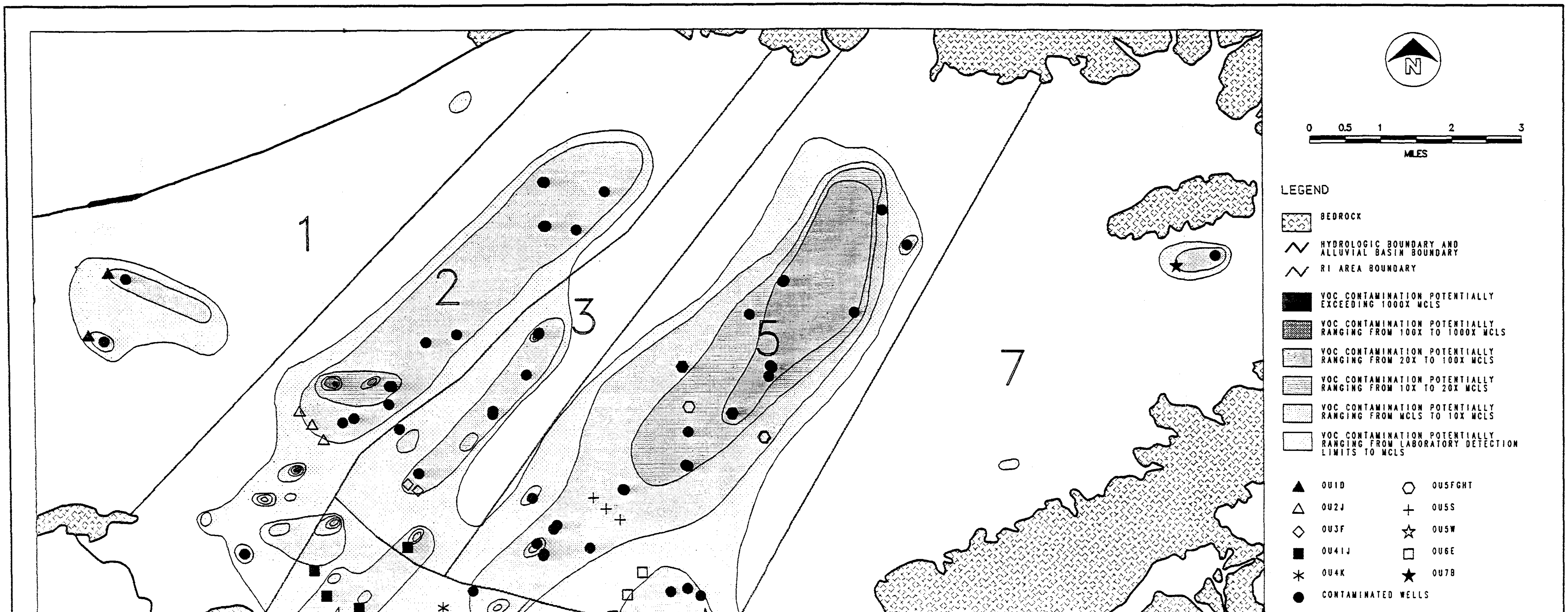
B.3.0 COST ESTIMATES - APPROACH AND ASSUMPTIONS

The cost estimates presented in this appendix are, at a minimum, Rough Order of Magnitude (ROM) estimates. A range of confidence of -30 percent to +50 percent is typically associated with this type of estimate. Additionally, in the case of these estimates, the uncertainty is compounded by that inherent to the assumptions described below and that associated with the numerical model described in Appendix C. Nevertheless, these cost estimates are intended solely for comparison of three broad, basinwide, technical approaches. As such, they are not considered to be highly accurate representations of the potential cost of undertaking the actions they describe.

B.3.1 INDIVIDUAL WELL TREATMENT

As described above, the first two objectives include the installation of VOC and nitrate treatment at individual wells. In the case of the first objective, the wells considered include both those presently contaminated as well as those predicted to be contaminated in twenty years, on the basis of the numerical model. Treatment was only considered (individually) for wells presently contaminated above Maximum Contaminant Levels (MCLs) for the second objective. Table B-1 lists the set of currently contaminated production wells and the capital and Operation and Maintenance (O&M) costs for each. Table B-2 presents the estimated costs for a larger group of production wells that are expected to be contaminated within the next twenty years. This latter set of wells includes those currently contaminated wells.

The Cost of Remedial Action (CORA [CH2M HILL, 1988]) cost model is the basis of the evaluations of the cost of treatment at individual wells. A separate cost model case is represented by the cost of treatment at each well. Industrial water-supply wells and irrigation wells were removed from the list to be estimated prior to processing. The CORA model costs have been adjusted from national average pricing to pricing for the greater Los Angeles area. Nitrate contamination has been assumed to be present in 75 percent of the wells on this list, at a concentration of 60 parts per million (ppm). Because there is no basis at present for specifying which of the 186 wells will be contaminated with nitrates (because nitrate migration has not been quantified), the cost of nitrate removal is estimated for an average well and then applied to 75 percent of the total number of wells in each scenario.



THE AREAS OF CONTAMINATION SHOWN IN THIS FIGURE REPRESENT GENERALIZED TWO-DIMENSIONAL APPROXIMATIONS BASED ON THE WATER QUALITY ANALYSES FROM PRODUCTION WELLS THAT VARY IN DEPTH AND PERFORATED INTERVALS.

DUE TO POSSIBLE VERTICAL ZONATION OF CONTAMINATION, A WELL LOCATED WITHIN AN IDENTIFIED AREA OF CONTAMINATION MAY PRODUCE WATER WITH CONTAMINANT CONCENTRATIONS DIFFERENT THAN THAT INDICATED ON THIS MAP.

AREAS OF CONTAMINATION ARE BASED ON AVAILABLE DATA FOR THE TIME PERIOD OF AUGUST 15, 1987 THROUGH MARCH 15, 1989, OR THE LAST RECORD FOR WELLS NOT SAMPLED IN THAT TIME PERIOD.

FIGURE B-2

SUMMARY OF ACTIONS FOR SINGLE-OBJECTIVE APPROACH:

CONTROL CONTAMINANT MIGRATION

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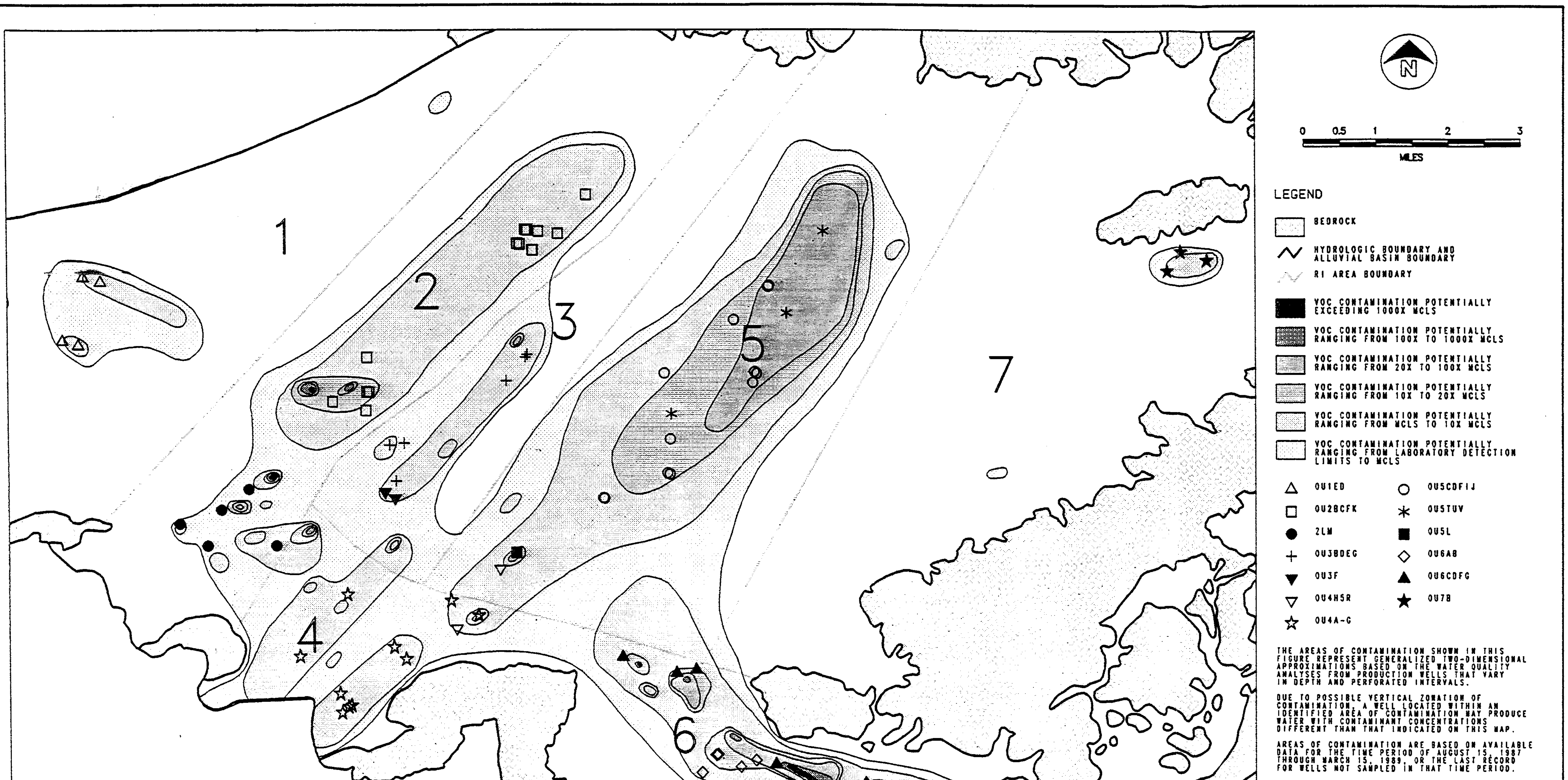

FIGURE B-3

SUMMARY OF ACTIONS FOR SINGLE-OBJECTIVE APPROACH:

REMOVE CONTAMINATION

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San Gabriel Basin

Table B-1
CURRENTLY CONTAMINATED WELL DATA USED IN SINGLE-OBJECTIVE COST ESTIMATES

WELL OWNER	WELL #	CAPACITY (GPM)	TCE	PCE	CTC	1,1-DCE	1,2-DCA	1,1,1-TCA	VOC TREATMENT CAP. COST	VOC TREATMENT O & M
			(All concentrations in ug/l)							
VCWD	1900031	2,900	38	7.6	9	3.1	3	0	$560,000	$150,000
VCWD	1900034	3,200	4.8	305	0	0	0	0	$1,100,000	$477,000
VCWD	1900035	3,700	130	4.8	7.6	1.3	8	0	$1,580,000	$641,000
MANNING BROTHERS	1900117	260	100	0	0	0	0	0	$160,000	$35,000
CAL - AM - DUARTE	1900356	1,680	7.9	0.8	0	1.2	0	0	$260,000	$63,000
MONROVIA, CITY OF	1900420	3,840	48	3.2	0	0	0	0	$1,020,000	$314,000
GLENDORA, CITY OF	1900831	1,820	8	0	0	25	0	0	$260,000	$67,000
COVINA IRRIG CO	1900882	2,860	52	8.9	3	2.1	0	0	$663,000	$263,000
COVINA IRRIG CO	1900883	2,450	195	7.9	0	0	0	0	$716,000	$292,000
COVINA IRRIG CO	1900885	2,280	6	1.9	1	0	0	0	$292,000	$85,000
HEMLOCK MUT W CO	1901178	170	0	10	0	0	0	0	$130,000	$33,000
CAL - AM - SAN MARINO	1901441	150	6.1	0.5	0	0	0	0	$120,000	$33,000
RICHWOOD	1901521	620	0	40	0	0	0	0		
RICHWOOD	1901522	232	0	87	0	0	0	0	$355,000	$109,000
SUBURBAN	1901596	990	23	0	0	0	0	0	$210,000	$49,000
SUBURBAN	1901621	150	19	41	0.19	0	0	0	$120,000	$33,000
SUBURBAN	1901627	1,900	0	12.1	0	0	0	0	$270,000	$66,000
SO. PASADENA, CITY OF	1901681	1,250	0	12.9	0	0	0	0	$230,000	$54,000
EL MONTE, CITY OF	1901693	320	0	19	0	0	0	0	$140,000	$36,000
EL MONTE, CITY OF	1901694	1,330	0	10	0	0	0	0	$230,000	$55,000
EL MONTE, CITY OF	1901695	490	12	0.8	0	0	0	0	$170,000	$40,000
SO CAL WTR CO	1902017	550	43	2.5	0	0	0	0	$195,000	$42,000
SO CAL WTR CO	1902018	360	140	6	0	20	0	0	$195,000	$39,000
SO CAL WTR CO	1902019	3,200	13.1	0	0	0	0	0	$515,000	$120,000
SO CAL WTR CO	1902027	670	11	2.9	0	0	0	0	$195,000	$42,000
SO CAL WTR CO	1902030	340	15	1.1	0	0	0	0	$165,000	$36,000
SO CAL WTR CO	1902031	340	86	12.7	2.9	0	0	0	$195,000	$38,000
SO CAL WTR CO	1902032	260	83	22	0	0	0	0	$165,000	$35,000
AZUSA VALLEY WTR CO	1902117	4,780	0	5.3	0	0	0	0	$598,000	$164,000
POLOPOLUS	1902169	40	87	30.7	1.1	8.3	0	0	$385,000	$49,000
SO CAL WATER CO	1902271	590	0.8	11.6	0	0	0	0	$180,000	$42,000
SO CAL WATER CO	1902461	780	12	0	0	0	0	0	$205,000	$45,000

Table B-1 (Continued)
CURRENTLY CONTAMINATED WELL DATA USED IN SINGLE-OBJECTIVE COST ESTIMATES

WELL OWNER	WELL #	CAPACITY (GPM)	TCE	PCE	CTC	1,1-DOE	1,2-DCA	1,1,1-TCA	VOC TREATMENT CAP. COST	VOC TREATMENT O & M
			(All concentrations in ug/l)							
INDUSTRY, CITY OF	1902582	1,050	1.4	0.84	3.5	7.6	0	0	$225,000	$50,000
LOS ANGELES, COUNTY OF	1902666	10	7.6	0.57	0	0.22	0.11	0	$245,000	$45,000
CAL - AM	1902787	270	9.6	0.86	0	0	0	0	$155,000	$35,000
HEMLOCK MUT WCO	1902806	150	0	5.4	0	0	0	0	$135,000	$33,000
WARD DUCK CO	1902951	500	9	140	0	4	0	0	$355,000	$109,000
ALHAMBRA, CITY OF	1903097	1,680	10	0	0	0	0	0	$275,000	$63,000
BEVERLY ACRES	8000004	100	5.6	4.8	0	1.2	0	0	$129,000	$33,000
VCWD	8000039	750	0.3	0	9	0	0	0	$195,000	$45,000
VCWD	8000060	4,200	39	1.6	3.1	0.6	0.6	0	$1,563,000	$601,000
SGVWCO	11900729	880	0.5	13.7	0	0	0	0	$205,000	$47,000
SGVWCO	21900749	1,290	7	1.8	0	0	0	0	$245,000	$55,000
SUBURBAN	31902819	1,040	18	37	0	16	0	0	$405,000	$123,000
SUBURBAN	31902820	1,500	18	37	0	15	0	0	$445,000	$143,000
SGVWCO	41900745	880	1	6.8	0	0	0	0	$205,000	$47,000
SGVWCO	51902858	3,460	13	3.8	3.9	0	0	0	$275,000	$63,000
SGVWCO	61900718	2,920	0.8	7.3	0.5	0.5	0	0	$285,000	$68,000
SGVWCO	71900721	1,880	42.1	1	4.2	0.43	2.3	0	$725,000	$273,000
SGVWCO	71903093	1,250	39	3.4	4.8	0.3	4.7	0	$575,000	$211,000
SGVWCO	81902525	1,160	4.7	7.5	0	1.1	0	0	$245,000	$53,000
SGVWCO	81902635	1,160	5.1	4.3	0	1.3	0	0	$245,000	$53,000
SGVWCO	91901437	1,410	34.71	4.89	8.32	2.43	0	0	$435,000	$143,000
SGVWCO	91901439	1,600	6.2	2.1	0.7	1.7	0	0	$275,000	$60,000
SGVWCO	98000068	2,500	6.1	0	0.6	1.9	0	0	$324,000	$85,000
SGVWCO	98000108	2,000	11.2	8.4	0	20	0	0	$505,000	$157,000
TOTAL COST									$20,250,000	$6,142,000
TOTAL COST ADJUSTED TO LA AREA (1.124)									$22,760,000	$6,904,000

WELL COUNT = 55

TOTAL CAPACITY = 78,142 GPM
AVERAGE CAPACITY = 1,420 GPM

Table B-2 (Page 1 of 7)
DATA USED IN SINGLE-OBJECTIVE COST ESTIMATES OF WELLS CONTAMINATED WITHIN TWENTY YEARS

WELL OWNER	WELL #	STATUS	CONC. (ppb)	CAPACITY (GPM)	STATE WELL NUMBER	OWNER WELL NUMBER/NAME	IMPL COST	ANNUAL O & M
RURBAN	1900120	P	25		1S/11W-14C01			
RURBAN	1900121	P	25	990	1S/11W-14C02		$230,000	$49,000
DEL RIO	1900331	P	25		1S/11W-34			
DEL RIO	1900332	P	25	300	1S/11W-34C11		$615,000	$123,000
VALLEY VIEW	1900363	P	25	1,089	1S/11W-12504		$215,000	$51,000
VALLEY VIEW	1900364	S	25	794	1S/11W-12505		$195,000	$46,000
VALLEY VIEW	1900365	S	25	226	1S/11W-12503		$615,000	$95,000
CHAMPION MUN CO.	1900908	P	25	2,853	1S/11W-14F03			
CAL DOSMESTIC	1901181	P	25	2,322	1S/11W-23P07		$300,000	$79,000
CAL DOSMESTIC	1901183	A	25	3,740	1S/11W-23P08		$525,000	$131,000
CEDAR AVE M W CO	1901411	P	25	180	1S/11W-15L01		$615,000	$89,000
LA PUENTE VCWD	1901460	P	25	2,818	1S/10W-19K01		$312,000	$95,000
SWS	1901602	R	25	860	1S/10W-306		$195,000	$47,000
SWS	1901627	P	25	1,895	1S/11W-26D02		$275,000	$66,000
INDUSTRY, CITY OF	1902581	S	25	950	1S/11W-26P02		$195,000	$48,000
INDUSTRY, CITY OF	1902582	S	25	1,050	1S/11W-26P01		$215,000	$50,000
EL MONTE, CITY OF	1902612	S	25	406	1S/11W-27F03		$155,000	$39,000
CHAMPION MU CO.	1902816	P	25	150	1S/11W-14F		$615,000	$89,000
LA PUENTE CWD	1902859	Q	25	900	1S/10W-19Q		$195,000	$47,000
WARD DUCK CO.	1902951	S	25	500	1S/11W-26L		$355,000	$109,000
CAL DOM	1902967	P	25	3,700	1S/11W-23P		$525,000	$131,000
SONOCO	1902971	P	25	210	1S/11W-26J15		$155,000	$35,000
VIA, H	1903012	A	25	100	1S/11W-24K		$555,000	$65,000
CAL DOM	1903057	P	25	4,330	1S/11W-23L		$552,000	$147,000
WARD DUCK CO.	1903072	P	25	240	1S/11W-35D			
CAL DOM	1903081	P	25	1,855	1S/11W-26D		$275,000	$65,000
VCWD	8000039	T	25	754	1S/10W-18F02		$195,000	$45,000
SCE	8000047	P	25	200	1S/11W-14F		$135,000	$35,000
LA PUENTE CWD	8000062	P	25	1,689	1S/10W-19Q		$265,000	$63,000
INDUSTRY, CITY OF	8000078	S	25	3,500	1S/11W-26P06		$505,000	$127,000
INDUSTRY, CITY OF	8000096	P	25	950	1S/11W-26P02		$195,000	$48,000
INDUSTRY, CITY OF	8000097	P	25	840	1S/11W-26P08		$225,000	$46,000
CAL DOM	8000100	P	25	3,740	1S/11W-23P08		$525,000	$131,000
SGVW CO	11900729	P	25	878	1S/11W-14E02		$195,000	$47,000
SGVW CO	11902946	P	25	1,661	1S/11W-14E		$265,000	$61,000

Table B-2 (Page 2 of 7)

DATA USED IN SINGLE-OBJECTIVE COST ESTIMATES OF WELLS CONTAMINATED WITHIN TWENTY YEARS

WELL OWNER	WELL #	STATUS	CONC. (ppb)	CAPACITY (GPM)	STATE WELL NUMBER	OWNER WELL NUMBER/NAME	IMPL COST	ANNUAL O & M
SGVW CO	41900739	P	25	1,353	1S/11W-34F01		$235,000	$56,000
SGVW CO	41900745	P	25	878	1S/11W-34F02		$195,000	$47,000
SGVW CO	41902713	P	25	1,080	1S/11W-34F03		$215,000	$51,000
SGVW CO	61900718	P	25	2,918	1S/11W-26K01		$320,000	$100,000
SGVW CO	61900719	P	25	3,250	1S/11W-26K		$505,000	$125,000
SGVW CO	71900721	A	25	1,881	1S/10W-19L01		$725,000	$273,000
SGVW CO	71903093	T	25	1,246	1S/10W-19L02		$575,000	$211,000
VCWD	1900035	T	25	3,700	1S/10W-17N01		$1,580,000	$641,000
COVINA IRRIG CO	1900882	T	25	2,861	1S/10W-17A03		$663,000	$263,000
COVINA IRRIG CO	1900883	T	25	2,450	1S/10W-17A02		$716,000	$292,000
COVINA IRRIG CO	1900885	T	25	2,275	1S/10W-17A01		$272,000	$78,000
SWS	1901597	N	25	878	1S/10W-20R01		$195,000	$47,000
SWS	1901598	P	25	3,765	1S/10W-20B05		$525,000	$131,000
SWS	1901599	P	25	2,923	1S/10W-20B09		$320,000	$100,000
SWS	1901610	E	25	286	1S/10W-20G01		$145,000	$35,000
SWS	1901611	E	25	381	1S/10W-20R		$155,000	$38,000
AZUZA VLY W. CO.	1902113	R	25	1,700	1S/10W-16B01		$265,000	$63,000
SURBURBAN	1902119	E	25	350	1S/10W-20N01		$150,000	$36,000
SURBURBAN	1902762	R	25	716	1S/10W-20Q01		$185,000	$44,000
SURBURBAN	1902763	S	25	508	1S/10W-29E01		$165,000	$40,000
KIYAN, HIDEO	1902970	P	25	40	1S/10W-29A		$385,000	$48,000
SWS	8000069	P	25	2,923	1S/10W-20B14		$320,000	$100,000
SWS	11902518	R	25	300	1S/10W-29G		$145,000	$36,000
SWS	1902519	P	25	613	1S/10W-30R01		$175,000	$42,000
SWS	1901616	N	25	574	1S/10W-33E03		$175,000	$41,000
SWS	1901608	P	25	920	1S/10W-32B01		$195,000	$48,000
SWS	1901623	P	25	523	1S/10W-31A03		$175,000	$42,000
SUBURBAN W S	1901430	P	25	1,355	2S/11W-5509		$235,000	$56,000
SUBURBAN W S	1901432	P	25	2,406	2S/11W-5055		$307,000	$82,000
SUBURBAN W S	1901433	P	25	1,800	2S/11W-505504		$265,000	$65,000
SUBURBAN W S	1901434	P	25	1,990	2S/11W-04N02		$275,000	$65,000
CAL - AM - SAN MARINO	1901441	Q	25	147	1S/11W-20B02		$124,000	$33,000
EL MONTE, CITY OF	1901692	P	25	1,870	1S/11W-21G02		$275,000	$65,000
EL MONTE, CITY OF	1901693	P	25	320	1S/11W-21G01		$145,000	$36,000
WHITTIER, CITY OF	1901745	P	25	3,110	2S/11W-05G01		$465,000	$100,000
WHITTIER, CITY OF	1901747	P	25	3,666	2S/11W-05G04		$525,000	$131,000

Table B-2 (Page 3 of 7)
DATA USED IN SINGLE-OBJECTIVE COST ESTIMATES OF WELLS CONTAMINATED WITHIN TWENTY YEARS

WELL OWNER	WELL #	STATUS	CONC. (ppb)	CAPACITY (GPM)	STATE WELL NUMBER	OWNER WELL NUMBER/NAME	IMPL COST	ANNUAL O & M
WHITTIER, CITY OF	1901748	S	25	1,130	2S/11W-05K01		$215,000	$53,000
WHITTIER, CITY OF	1901749	P	25	1,689	2S/11W-05G02		$265,000	$63,000
SO CAL WTR CO	1902031	T	25	340	1S/11W-16M		$195,000	$38,000
SO CAL WTR CO	1902032	T	25	260	1S/11W-16M		$165,000	$35,000
LOS ANGELES, COUNTY OF	1902579	P	25	1,460	2S/11W-05B		$245,000	$59,000
LOS ANGELES, COUNTY OF	1902580	P	25	930	1S/11W-32Q02		$195,000	$48,000
CAL - AM	1902787	Q	25	1,270	1S/11W-20B04		$145,000	$35,000
EL MONTE, CITY OF	1903137	P	25	2,375	1S/11W-21F02		$305,000	$81,000
BEVERLY ACRES	8000004	P	25	100	2S/11W-08H		$555,000	$65,000
WHITTIER, CITY OF	8000071	P	25	3,676	1S/11W-05C07		$525,000	$131,000
WHITTIER NARROWS NAT CTR	8000088	P	25	380	2S/11W-04D		$155,000	$38,000
WHITTIER NARROWS NAT CTR	8000089	P	25	730	2S/11W-05E		$185,000	$44,000
LOS FLORES MUT WTR CO	11902098	R	25		1S/11W-29			
LOS FLORES MUT WTR CO	21902098	R	25	50	1S/11W-29		$385,000	$51,000
SGVW CO	81902635	P	25	1,157	2S/11W-04G01		$235,000	$53,000
EL MONTE, CITY OF	8000101		25	730	(#13)		$185,000	$44,000
EL MONTE, CITY OF	1901694	T	25	1,329	1S/11W-21Q01		$235,000	$55,000
EL MONTE, CITY OF	1901699	P	25	2,149	1S/11W-21H01		$287,000	$74,000
SGVW CO	81902525	R	25	1,157	2S/11W-04		$235,000	$53,000
SCE	1900343	S	25	20	1S/11W-24S01		$235,000	$45,000
MONTEREY PARK, CITY OF	1900453	P	25	1,100	1S/12W-25B01		$215,000	$51,000
MONTEREY PARK, CITY OF	1900454	P	25	732	1S/12W-25B02		$235,000	$55,000
MONTEREY PARK, CITY OF	1900455	P	25	1,113	1S/12W-25B07		$215,000	$51,000
MONTEREY PARK, CITY OF	1900456	P	25	427	1S/12W-25B08		$155,000	$39,000
MONTEREY PARK, CITY OF	1900457	P	25	2,057	1S/12W-25G05		$275,000	$65,000
MONTEREY PARK, CITY OF	1900458	P	25	644	1S/12W-25G04		$175,000	$42,000
SO CAL WTR CO	1900510	P	25	1,359	1S/12W-25B10		$235,000	$56,000
SO CAL WTR CO	1900511	P	25	825	1S/12W-25B11		$195,000	$46,000
SO CAL WTR CO	1900512	S	25	255	1S/12W-25B05		$155,000	$36,000
SO CAL WTR CO	1900513	S	25	232	1S/12W-25B03		$155,000	$35,000
SO CAL WTR CO	1900514	P	25	446	1S/12W-24E04		$165,000	$35,000
SO CAL WTR CO	1900515	P	25	347	1S/12W-24E		$155,000	$36,000
SGVW CO	1900725	P	25	855	1S/11W-19M01		$195,000	$47,000
AMARILLO MW CO	1900791	P	25	1,096	1S/11W-19E04		$215,000	$51,000
AMARILLO MW CO	1900792	P	25	549	1S/11W-19E03		$175,000	$41,000
CAL AM - SAN MARINO	1900918	P	25	518	1S/11W-18K01		$115,000	$40,000
CAL AM - SAN MARINO	1900923	P	25	794	1S/11W-19F01		$195,000	$47,000

Table B-2 (Page 4 of 7)
DATA USED IN SINGLE-OBJECTIVE COST ESTIMATES OF WELLS CONTAMINATED WITHIN TWENTY YEARS

WELL OWNER	WELL #	STATUS	CONC. (ppb)	CAPACITY (GPM)	STATE WELL NUMBER	OWNER WELL NUMBER/NAME	IMPL COST	ANNUAL O & M
SO CAL WTR CO	1902144	P	25	439	1S/12W-25A01		$155,000	$39,000
MONTEREY PARK, CITY OF	1902372	P	25	1,100	1S/11W-30F01		$215,000	$51,000
MONTEREY PARK, CITY OF	1902373	P	25	1,930	1S/11W-30E03		$275,000	$65,000
LOS ANGELES, COUNTY OF	1902663	P	25	290	1S/11W-31C02		$145,000	$36,000
LOS ANGELES, COUNTY OF	1902664	P	25		1S/11W-30P02			
LOS ANGELES, COUNTY OF	1902666	T	25	230	1S/11W-30G02		$245,000	$45,000
MONTEREY PARK, CITY OF	1902690	P	25	1,682	1S/11W-30F03		$265,000	$61,000
MONTEREY PARK, CITY OF	1902818	P	25	1,329	1S/12W-25B12		$235,000	$55,000
CAL AM	1902867	Q	25	587	1S/11W-19F02		$175,000	$42,000
MONTEREY PARK, CITY OF	1903033	P	25	2,187	1S/11W-30M02		$290,000	$75,000
MONTEREY PARK, CITY OF	1903092	Q	25	1,860	1S/12W-25J01		$275,000	$63,000
SO CAL EDISON	11900344	Q	25		1S/12W-25K02			
SO CAL EDISON	21900344	Q	25	120	1S/12W-25K02		$121,000	$33,000
RICHWOOD	1901521	S	25		1S/12W-15Q03			
RICHWOOD	1901522	S	25	294	1S/12W-15Q01		$355,000	$109,000
ALHAMBRA, CITY OF	1900010	P	25	2,318	1S/12W-11N02		$300,000	$79,000
ALHAMBRA, CITY OF	1900013	S	25	568	1S/12W-10R01		$175,000	$41,000
SG CO WTR DIST	1901672	R	25	1,000	1S/12W-11D01	08	$230,000	$49,000
SO. PASADENA, CITY OF	1901681	P	25	1,250	1S/12W-02Q01	WILSON 2	$235,000	$54,000
SO. PASADENA, CITY OF	1901682	P	25	1,916	1S/12W-02Q03	WILSON 3	$275,000	$65,000
SG CO WTR DIST	1902785	S	25	1,527	1S/12W-12C01	09	$245,000	$59,000
SO. PASADENA, CITY OF	1903086	P	25	1,029	1S/12W-02Q04	WILSON 4	$215,000	$49,000
ALHAMBRA, CITY OF	1903097	P	25	1,681	1S/12W-11K	07	$265,000	$61,000
CAL - AM - SAN MARINO	1900921	P	25	436	1S/12W-13A01	RIC-1	$155,000	$39,000
CAL - AM - SAN MARINO	1900926	P	25	1,130	1S/11W-07N02	1948	$215,000	$51,000
CAL - AM - SAN MARINO	1900927	P	25	1,063	1S/11W-07N01	1957 GRAND	$215,000	$50,000
SG CO WTR DIST	1901669	P	25	2,488	1S/12W-13B01	BRA 5	$313,000	$85,000
CAL - AM - SAN MARINO	1902424	P	25	628	1S/12W-17B05	1958-HOWLAND	$175,000	$42,000
CAL - AM - SAN MARINO	1903019	P	25	1,357	1S/11W-08J07	MARIPOSA 3	$235,000	$56,000
SG CO WTR DIST	8000067	P	25	1,827	1S/12W-13B3	11	$275,000	$65,000
EL MONTE, CITY OF	1901695	P	25	494	1S/11W-16N01	05	$165,000	$40,000
ARCADIA, CITY OF	1902791	P	25	950	1S/11W-08A03	2 BALANCE	$195,000	$48,000
CAL - AM - DUARTE	1900356	T	25	1,684	1N/11W-36L01	MT. AVE	$265,000	$63,000
MONROVIA, CITY OF	1900420	P	25	3,843	1S/11W-02H01	04	$1,020,000	$314,000

Table B-2 (Page 5 of 7)
DATA USED IN SINGLE-OBJECTIVE COST ESTIMATES OF WELLS CONTAMINATED WITHIN TWENTY YEARS

WELL OWNER	WELL #	STATUS	CONC. (ppb)	CAPACITY (GPM)	STATE WELL NUMBER	OWNER WELL NUMBER/NAME	IMPL COST	ANNUAL O & M
VALLEY CO WATER DIST	1900027	P	25	1,200	1S/10W-07A06	EAST MAINE-1	$230,000	$53,000
VALLEY CO WATER DIST	1900028	S	25	850	1S/10W-07A07	WEST MAINE-2	$225,000	$46,000
VALLEY CO WATER DIST	1900032	P	25	1,445	1S/10W-07A02	JOANBRIDGE EAST-6	$245,000	$58,000
VALLEY CO WATER DIST	1900034	T	25	3,200	1S/10W-08A02	8-ARROW HWY	$1,100,000	$477,000
POLOPOLUS, ET. AL.	1902169	R	25	40	1S/10W-08L	01	$385,000	$48,000
VALLEY CO WTR DIST	1902356	P	25	2,656	1S/10W-07A01	JOANBRIDGE WEST-3WT	$301,000	$91,000
VALLEY CO WTR DIST	8000060	P	25	4,200	1S/10W-08A03	10 LANTE	$1,563,000	$601,000
LOS ANGELES, COUNTY OF	8000070	P	25	1,120	1S/10W-05A1	SANTA FE 1	$215,000	$171,000
MILLER BREWING CO.	8000075	P	25	2,270	1N/10W-33H1	01	$271,000	$78,000
VALLEY CO WTR DIST	1900029	T	25	1,370	1S/10W-04R02	(MORADA)3)	$235,000	$56,000
MANNING BROTHERS	1900117	A	25	260	1S/10W-09H	36230	$160,000	$35,000
GLENDORA, CITY OF	1900831	T	25	1,821	1S/10W-03C03	07G	$265,000	$65,000
AZUSA, CITY OF	1902537	S	25	3,636	1N/10W-34L01	05	$525,000	$131,000
SO CAL WTR DIST-SAN DIMAS	1902270	P	25	331	1S/9W-05G	COLUMBIA 6	$195,000	$36,000
SO CAL WTR DIST-SAN DIMAS	1902271	P	25	588	1S/9W-05J01	COLUMBIA 7	$175,000	$41,000
SG VALLEY WTR CO	91901435	R	75	2,170	1S/10W-31P	B-7A	$373,000	$81,000
SG VALLEY WTR CO	98000068	S	75	2,500	1S/10W-31P	B-7C	$407,000	$94,000
SG VALLEY WTR CO	91901440	A	75	1,000	1S/10W-31P05	07B	$245,000	$51,000
SUBURBAN WTR SYS	1900337	S	75	437	1S/10W-31G03	152W1	$185,000	$40,000
SG VALLEY WTR CO	91901439	Q	75	1,600	1S/10W-31F	B11A	$505,000	$157,000
SG VALLEY WTR CO	98000108	S	75	2,000	1S/10W-31F	B11B	$355,000	$75,000
SUBURBAN WTR SYS	1901596	A	75	992	1S/10W-31G04	147W1	$245,000	$51,000
SUBURBAN WTR SYS	1902760	A	75	290	1S/10W-31G	147W2	$165,000	$36,000
SG VALLEY WTR CO	91901436	R	75	2,480	1S/10W-31L	B8	$405,000	$93,000
SUBURBAN WTR SYS	8000077	P	75	2,739	1S/10W-31C01	147W3	$430,000	$103,000
SG VALLEY WTR CO	51902858	P	75	3,457	1S/11W-24Q07	B4B	$315,000	$65,000
SG VALLEY WTR CO	51902947	P	75	3,200	1S/11W-24Q08	B4C	$585,000	$127,000
VALLEY CO WTR DIST	1900031	P	75	2,900	1S/10W-19C01	PADDY LANE 5	$560,000	$150,000
SG VALLEY WTR CO	31900736	P	75	831	1S/11W-30B01	8A	$235,000	$48,000
SG VALLEY WTR CO	31900746	P	75	905	1S/11W-30B02	8B	$245,000	$49,000
SG VALLEY WTR CO	31900747	P	75	973	1S/11W-30B03	8C	$245,000	$51,000
SG VALLEY WTR CO	31903103	P	75	3,400	1S/11W-30B04	8D	$315,000	$65,000
LOS ANGELES, COUNTY OF	1902665	P	75	410	1S/11W-30G01	WHITTIER 5	$185,000	$40,000
SO CAL WTR CO - SG	1902024	P	75	837	1S/11W-18A	ENCINITAS 1	$235,000	$48,000
SO CAL WTR CO - SG	1902035	P	75	924	1S/11W-18A	ENCINITAS 2	$245,000	$49,000
ADAMS RCH MUTUAL WTR CO	1902106	P	75	180	1S/11W-18H	01	$145,000	$35,000
ADAMS RCH MUTUAL WTR CO	1902689	Q	75	180	1S/11W-18H	02	$145,000	$35,000

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DATA USED IN SINGLE-OBJECTIVE COST ESTIMATES OF WELLS CONTAMINATED WITHIN TWENTY YEARS

WELL OWNER	WELL #	STATUS	CONC. (ppb)	CAPACITY (GPM)	STATE WELL NUMBER	OWNER WELL NUMBER/NAME	IMPL COST	ANNUAL O & M
SO CAL WTR CO - SG	8000073	P	75	0	1S/11W-18A	ENCINITAS 3	$235,000	$48,000
HEMLOCK MUTUAL WTR CO	1901178	P	75	170	1S/11W-11P	NORTH	$145,000	$34,000
HEMLOCK MUTUAL WTR CO	1902806	P	75	149	1S/11W-11P	SOUTH	$135,000	$33,000
SUBURBAN WTR SYS	1901621	E	100	146	2S/10W-08L01	131W1	$145,000	$33,000
SUBURBAN WTR SYS	1901625	R	100	469	1S/10W-08K01	136W1	$335,000	$109,000
SWS - VICTORIA WTR CO	31902819	T	100	1,035	2S/10W-08E01	155W1	$445,000	$136,000
SWS - VICTORIA WTR CO	31902820	T	100	1,500	2S/10W-08E02	155W2	$525,000	$157,000
SG VALLEY WTR CO	91901437	A	100	1,410	1S/10W-31E	B9	$495,000	$150,000
EL MONTE, CITY OF	1901700	R	100	30	1S/11W-20L01	11	$235,000	$46,000
SO CAL WTR CO	1902017			550			$195,000	$42,000
SO CAL WTR CO	1902018			360			$195,000	$39,000
SO CAL WTR CO	1902019			3,200			$515,000	$120,000
SO CAL WTR CO	1902027			670			$195,000	$42,000
AZUSA VALLEY WTR CO	1902117			4,780			$598,000	$164,000
SO CAL WATER CO	1902461			780			$205,000	$45,000
SGVWCO	21900749			1,290			$245,000	$55,000
WELL COUNT = 186							$56,475,000	$14,565,000
TOTAL COST							$63,480,000	$16,371,000
TOTAL COST ADJUSTED TO LA AREA (1.124)								
TOTAL CAPACITY 1,330 GPM/WELL								

Notes:

A. Pumping rates are the highest acre-foot-per-quarter rate reported.

B. Status codes are as follows:

A - Abandoned
D - Diversion
E - Not in service, No electricity
N - Not in service, Nitrate contamination
O - Observation
P - Producing
Q - Not in service, Reason unknown
R - Not in service, Pump removed
S - Not in service, Still operational
T - Not in service, VOC contamination
X - Not a well

Table B-2 (Page 7 of 7)
DATA USED IN SINGLE-OBJECTIVE COST ESTIMATES OF WELLS CONTAMINATED WITHIN TWENTY YEARS

WELL OWNER	WELL #	STATUS	CONC. (ppb)	CAPACITY (GPM)	STATE WELL NUMBER	OWNER WELL NUMBER/NAME	IMPL COST	ANNUAL O & M

c. VOC concentration are in ug/l and have been assinged as the approximate median of zones bounded by contours in the 20-year scenario developed with the finite-element model.

B.3.2 OPERABLE UNITS

The latter two objectives include the implementation of sets of operable units described in Appendix B. For the second objective, Control Contaminant Migration, operable-unit costs are added to the cost of treatment at presently contaminated wells. The third objective, Remove Contamination, is made up solely of operable units that remove large amounts of contaminants from the central portions of contaminated areas. The overall approach to developing cost estimates for the operable units in these scenarios is similar to that described in Appendix E. In fact, the estimates developed in Appendix E for eight representative operable units form the basis for the operable-unit estimates described below. As with the development of the stage cost evaluations presented in Sections 6.0 through 9.0, operable units not specifically evaluated in Appendix E have been priced by factoring their cost from a similar OU among the eight representative OUs in Appendix E.

The cost estimates in Appendix E are based on the two distribution scenarios described for each operable unit in Appendix D. In the cost estimates described in this appendix, the median of the two Appendix E estimates for each operable unit is used. As described in Appendix D, two different distribution scenarios are developed because (1) cost estimates are conceptual and used only for comparative purposes at this stage, and (2) there is at present no available basis for more detailed evaluations. The cheaper of the two distribution scenarios is also considered to be the closest to the actual scenario that will be developed as part of the FS of each operable unit. Therefore, these operable unit costs, which are based on the median of Appendix E costs, may be higher than actual implementation costs.

B.3.3 OPERATION AND MAINTENANCE COSTS

The O&M costs associated with individual well treatment have been evaluated over 30 years at discount rates of 3, 5, and 10 percent per annum for both VOC- and nitrate-removal technologies. For the first objective, it is assumed that treatment units for the currently contaminated wells are installed immediately; the balance of the wells are assumed to receive treatment evenly over the next twenty years in five-year increments. For the O&M costs associated with individual treatment for the second objective, it is assumed that all presently contaminated wells will receive treatment immediately.

Operable-unit O&M costs are based on those described for the eight operable units evaluated in Appendix E. As with the capital costs of other operable units not included in Appendix E, O&M costs have been extrapolated on the basis of differences in size, location, and technologies utilized. Annual costs have been converted to cumulative costs over 30 years using a discount rate of 10 percent per annum.

Costs of treatment at individual wells have been calculated using the CORA model which assumes a variety of costs not considered in the estimates of treatment at operable units. These include the cost of insurance, permit renewal, and various contingencies, among others. To account for this difference in approach, and to maintain an even basis for comparison of operable-unit and individual-well cost estimates, the CORA costs have been adjusted accordingly. Nevertheless, two additional issues should be noted and considered when comparing the cost of operating operable units and treatment facilities installed at individual wells:

1. Administrative costs associated with operating numerous treatment facilities at numerous locations are higher than those associated with a smaller number of centralized facilities. This difference is probably not adequately accounted for in the O&M cost estimates.

2. Although capital cost estimates are based on the treatment required to treat wells pumping at their capacity, actual pumping rates are likely to be considerably less than the capacity of the well. Therefore, although the capital cost estimate should reflect design to well capacity, O&M costs are likely to be less than those estimated in this appendix.

These two points appear to affect the cost estimates in opposing ways. Because considerable additional analysis would be required to estimate the magnitude of error introduced by each, it is difficult to assess whether the estimates are higher or lower than they should be.

B.4.0 COST ESTIMATES - RESULTS

The basic components of the cost estimate for the first objective are listed in Table B-3. The cost of VOC treatment was summarized in Table B-2. Nitrate treatment was estimated on the basis of factors explained in Section B.3.1. The sum of these two items yields a total capital cost of $107,706,000. When thirty years of O&M are added, the cost increases to between $224,043,000 and $392,855,000, depending on the discount rate used in calculating the present value.

The second objective, control contaminant migration, combines the cost of installing wellhead treatment on wells currently contaminated, with the implementation of eleven OUs designed specifically to control the migration of contaminants. These costs are summarized in Table B-4. The operable unit costs listed in Table B-4 are based on their descriptions in Appendix A.

Table B-3
COST SUMMARY
MAINTAIN AN ADEQUATE WATER SUPPLY
($ X 1,000)

Cost of Implementation	
VOC Removal Facilities	63,480
Nitrate Removal Facilities	44,226
Total Implementation Cost	107,706
Operation and Maintenance	
Cumulative value over 30 years	
(Present value at 10% discount rate)	116,337
(Present value at 5% discount rate)	213,221
(Present value at 3% discount rate)	285,149
Total Cost of First Objective	
(Using O&M present value at 10%)	224,043
(Using O&M present value at 5%)	320,927
(Using O&M present value at 3%)	392,855

Included in these costs are basic RI costs, and the median of costs associated with the two types of distribution alternatives described in Appendix E. The total capital cost associated with implementation of the operable units is $168,840,000. In the cost estimates of both the second and third objectives, treatment facilities are assumed to be installed immediately and operated for thirty years. With the addition of treatment at currently contaminated wells and thirty years of O&M for both well treatment and operable units, the total cost of this single-objective approach totals between $373,069,000 and $519,385,000, depending on the discount rate used.

The costs associated with the third approach, contaminant removal, are presented in Table B-5. The operable unit cost estimates include nitrate treatment and RI costs, based on descriptions presented in Appendix A. As before, operable unit costs are based on medians of ranges that describe two types of distribution alternatives (Appendices D and E). The total implementation cost of these contaminant removal operable units is $304,730,000; the total cost is estimated at between $396,990,000 and $511,040,000 with 30 years of O&M, depending on the discount rate.

Table B-4
COST SUMMARY
CONTROL CONTAMINANT MIGRATION
($ X 1,000)

ITEM	COST
Operable Unit 1D	8,590
Operable Unit 2J	23,740
Operable Unit 2LM	24,060
Operable Unit 3F	16,400
Operable Unit 4IJ	12,850
Operable Unit 4K	18,960
Operable Unit 5FGHT	24,340
Operable Unit 5S	21,380
Operable Unit 5W	20,880
Operable Unit 6E	25,470
Operable Unit 7B	4,500
Total Operable Unit Capital Cost	201,170
Individual Treatment at Currently Contaminated Wells	
VOC Treatment	22,760
Nitrate Treatment	13,470
Total Capital Cost	237,400
O&M Cost for Thirty Years	
(Present value at 10% discount rate)	135,669
(Present value at 5% discount rate)	221,128
(Present value at 3% discount rate)	281,985
Total Cost	
(Using O&M present value at 10%)	373,069
(Using O&M present value at 5%)	458,528
(Using O&M present value at 3%)	519,385

Table B-5
COST SUMMARY
REMOVE CONTAMINATION
($ x 1,000)

ITEM	COST
Operable Unit 1ED	17,100
Operable Unit 2BCFK	53,420
Operable Unit 2LM	24,060
Operable Unit 3BDEGF	23,480
Operable Unit 4H5R	10,660
Operable Unit 4A-G	30,330
Operable Unit 5CDGFIJ	72,060
Operable Unit 5TUV	32,900
Operable Unit 5L	2,570
Operable Unit 6AB	11,430
Operable Unit 6CDFG	22,220
Operable Unit 7B	4,500
Total Capital Cost	304,730
O&M Cost for Thirty Years	
(Present value at 10% discount rate)	92,260
(Present value at 5% discount rate)	161,785
(Present value at 3% discount rate)	206,310
Total Cost	
(Using O&M present value at 10%)	396,990
(Using O&M present value at 5%)	466,515
(Using O&M present value at 3%)	511,040

One of the less certain aspects of these estimates is the cumulative O&M cost. Because these estimates are considered approximate and to be used only comparatively, the 30-year time frame was assumed for all 3 objectives. The length of time over which treatment would be installed on a well-by-well basis to meet the first objective (assumed to be 20 years) required the extensive 30-year period to be applied to all 3 objectives.

Because the O&M costs associated with the three approaches are accrued differently, the uncertainty associated with the choice of discount rate also varies. As shown in Figure B-4, O&M costs remain constant over time for the

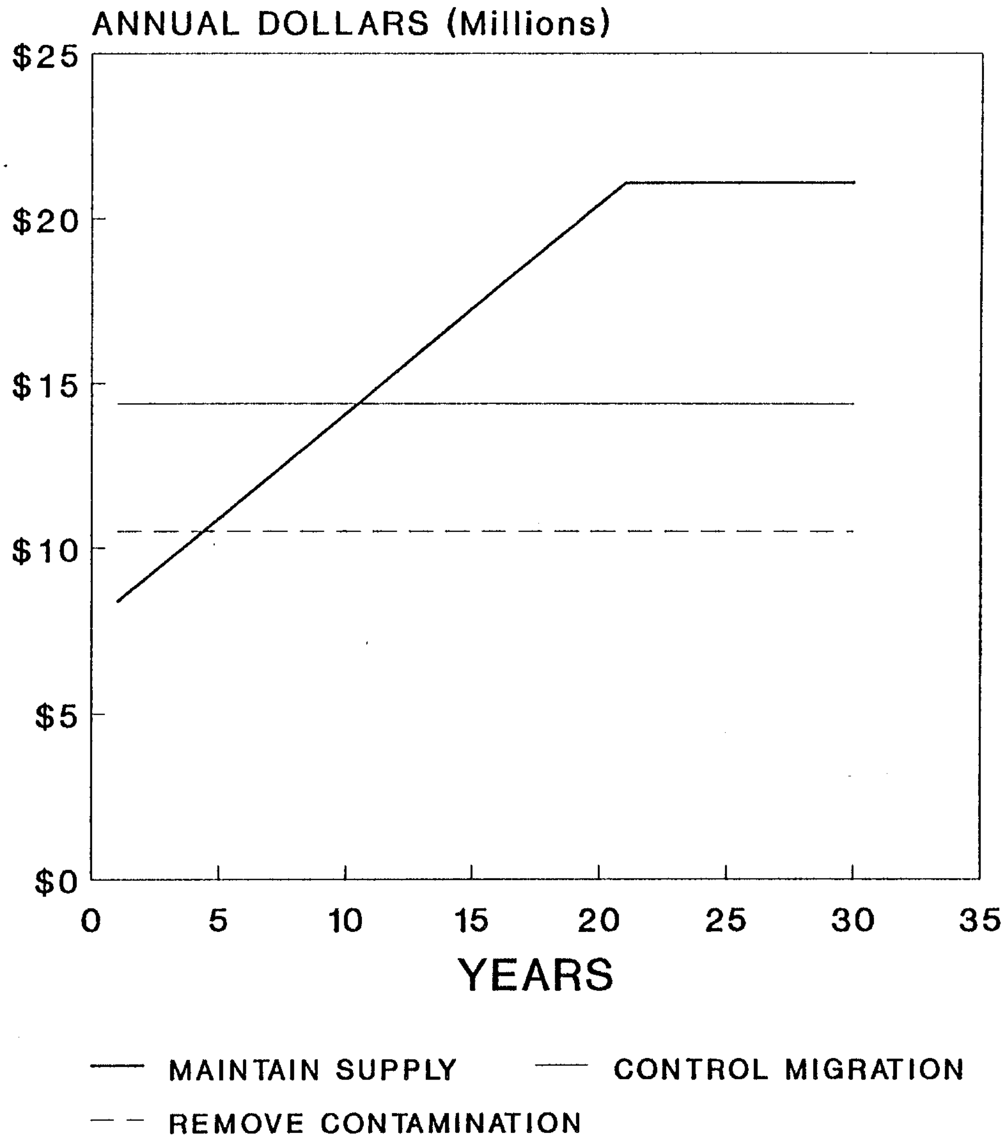

FIGURE B-4

ANNUAL O&M COSTS OVER THIRTY YEARS

DRAFT BASINWIDE TECHNICAL PLAN
SAN GABRIEL BASIN

second two objectives. Although the approaches to all three objectives are conceptual, it appears certain that the O&M costs required to operate and maintain treatment units that are installed at wells as they become contaminated are likely to grow considerably as the number of treatment units grows. Therefore, O&M costs, initially higher for the second two objectives, are ultimately highest for the first objective. The uncertainty associated with these costs is, accordingly, highest for the first objective.

B.5.0 REFERENCES

U.S. Environmental Protection Agency. Cost of Remedial Action Model, Uses Manual. Prepared for EPA Office of Solid Waste and Emergency Response. June 30, 1988.

Appendix C
GROUNDWATER FLOW AND CONTAMINANT TRANSPORT

APPENDIX C

CONTENTS

TABLES

FIGURES

FIGURES (Continued)

Appendix C
GROUNDWATER FLOW AND CONTAMINANT TRANSPORT

C.1.0 INTRODUCTION

This appendix describes numerical simulations performed to support the assessments of current water management practices presented in Section 2.0, and the evaluations of operable units (OU) described in Section 5.0. To estimate the effects of water management practices without remedial action on the current extent and migration of groundwater contaminated with volatile organic compounds (VOCs) in the San Gabriel Basin, numerical techniques were performed to simulate groundwater flow and contaminant transport for the last 10 years, and the next 10 and 20 years.

The numerical simulations described in this appendix were performed using a numerical model described in the Draft Report of Remedial Investigations (EPA, 1989b). This model was generated using the finite-element Coupled Fluid, Energy and Solute Transport Model (CFEST) code (Gupta, et. al., 1987). Calibration of the groundwater-flow portion of this model is described elsewhere (EPA, 1989b); calibration of the contaminant transport portion of the model will be briefly described in Section C.2.0, below.

Eight OUs have been selected as a representative subset of the 38 OUs presented in Appendix A. Selection of the subset is described in Chapter 5.0. A general discussion of the procedures and methods used to modify the existing model to simulate remedial actions is presented in Section C.3.0, followed by a description of specific numerical model modifications for each of the eight OUs evaluated. A detailed discussion of the results for each OU simulation will follow.

C.2.0 APPROACH TO TRANSPORT SIMULATIONS

The regional effects of continuing existing practices have been estimated using a three-dimensional model that accounts for groundwater pumping, recharge from precipitation, artificial recharge at spreading basins, groundwater-surface water interaction, and subsurface flow across the lateral boundaries of the model. Previous work (EPA, 1989b) showed that the simulated results (groundwater levels, flow directions, boundary flows) compared well with what was actually measured or calculated from field data. The good comparison indicates that the model is an effective tool to evaluate the regional groundwater flow in the basin. The process of adjusting model parameters until simulated data match the observed data is called "calibrating" the model. Although the agreement between observed and simulated parameters appears good and the model is quite sophisticated (with 4 layers and over 3,000 nodes), the model represents a significant simplification of the actual aquifer. Consequently, local conditions may vary from the regional results.

The flow fields (directions and rates of groundwater flows) calculated by this model are used to estimate the transport of contaminants in the subsurface for several scenarios. Although the groundwater-flow portion of the model appears consistent with observed conditions, transport parameters need to be defined to match conditions in the natural system. This is done iteratively until simulated and observed conditions are similar. Calibrating a contaminant transport model is more difficult than calibrating a flow model because key data are almost never known. The most uncertain parameters in the San Gabriel model are the locations, timing, and strengths of contaminant sources. The modeling approach assumes that possible sources are generally located at the upgradient edges of the main areas of high contamination, as currently defined (see Figure 1-2). Modeling sensitivity runs suggest that without continuing contaminant input, vertical and horizontal mixing of contaminants would cause concentrations to dissipate more quickly than has been observed. Although variations in the types of VOCs within general areas of contamination suggest multiple sources may be present, the modeling approach limited the numbers and locations of sources to those shown in Figure C-1, so as not to bias the analysis toward overly negative results, and to facilitate the analysis.

To test the ability of the model to replicate observed conditions of contaminant migration, simulations were performed representing conditions in the basin since 1980. The locations and magnitude of the sources in Figure C-1 were adjusted during the calibration process. In addition to adjustments to the source terms, the initial conditions of these simulations were also repeatedly modified to some degree to allow a better match of the final results of the simulation with observed conditions today. Much fewer data are available concerning the extent of contamination in 1980. Initial estimates of 1980 contamination and subsequent modifications were all consistent with available data. The final estimate of 1980 contamination used as an initial condition for simulations of historical contaminant migration is shown in Figure C-1.

Figure C-2 compares the distribution of contaminants simulated with the historical model, with the extent of contamination in 1989 interpreted from available data, as shown in Figure 1-2. Comparison suggests that reasonably estimated model parameters lead to a solution that is consistent with what has been observed. These calculations suggest that the areal extent of contamination may have increased by 9 square miles over the last 9 years and that 40 wells may have become contaminated above Maximum Contaminant Levels (MCLs). Simulations of future conditions that begin with the extent of contamination observed today are based on initial conditions that are defined directly from the current interpreted extent of contamination (Figure 1-2), and not with the extent simulated with historical simulations.

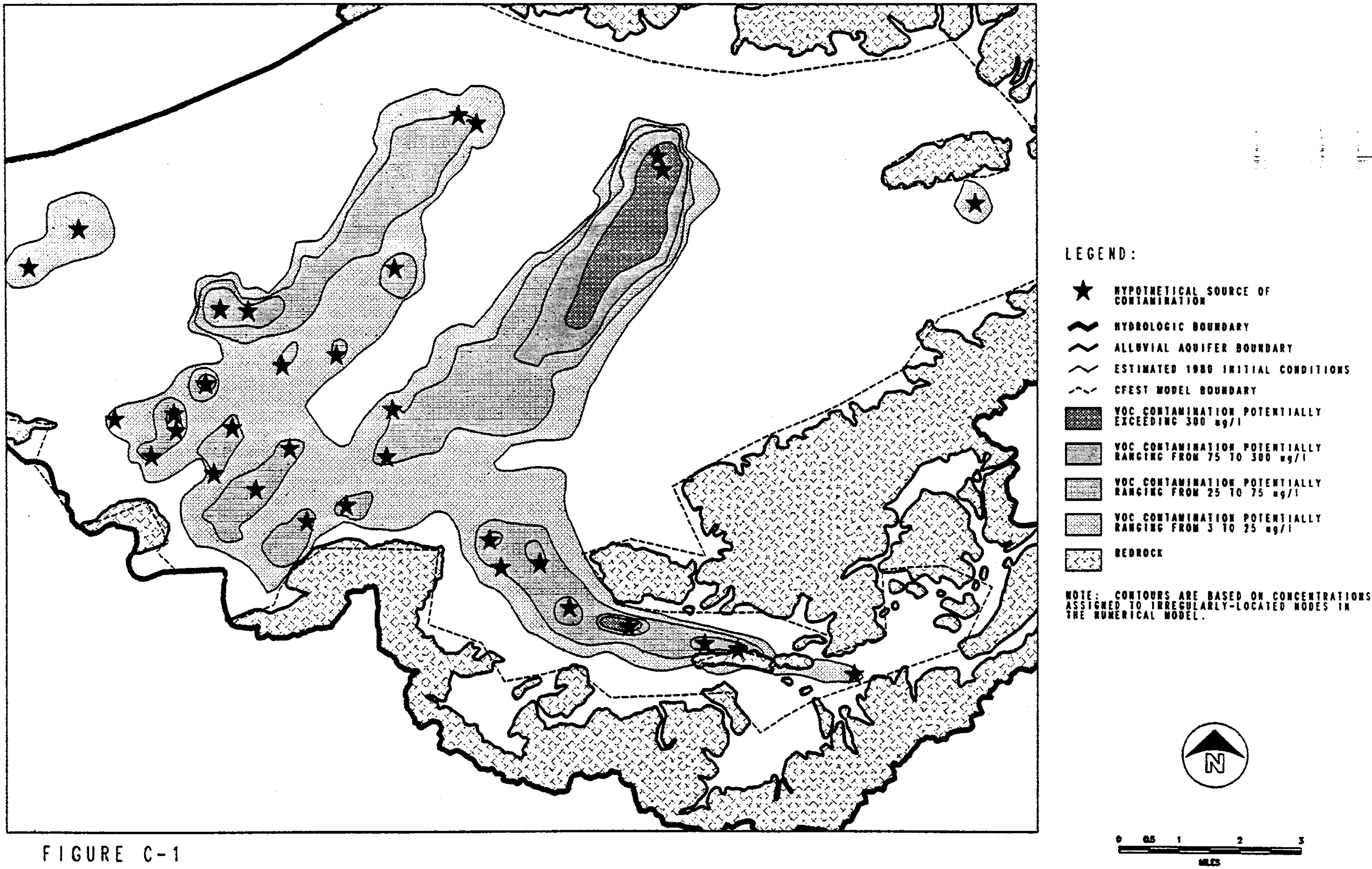

FIGURE C-1

ASSUMED 1980 CONTAMINATION AND SOURCES

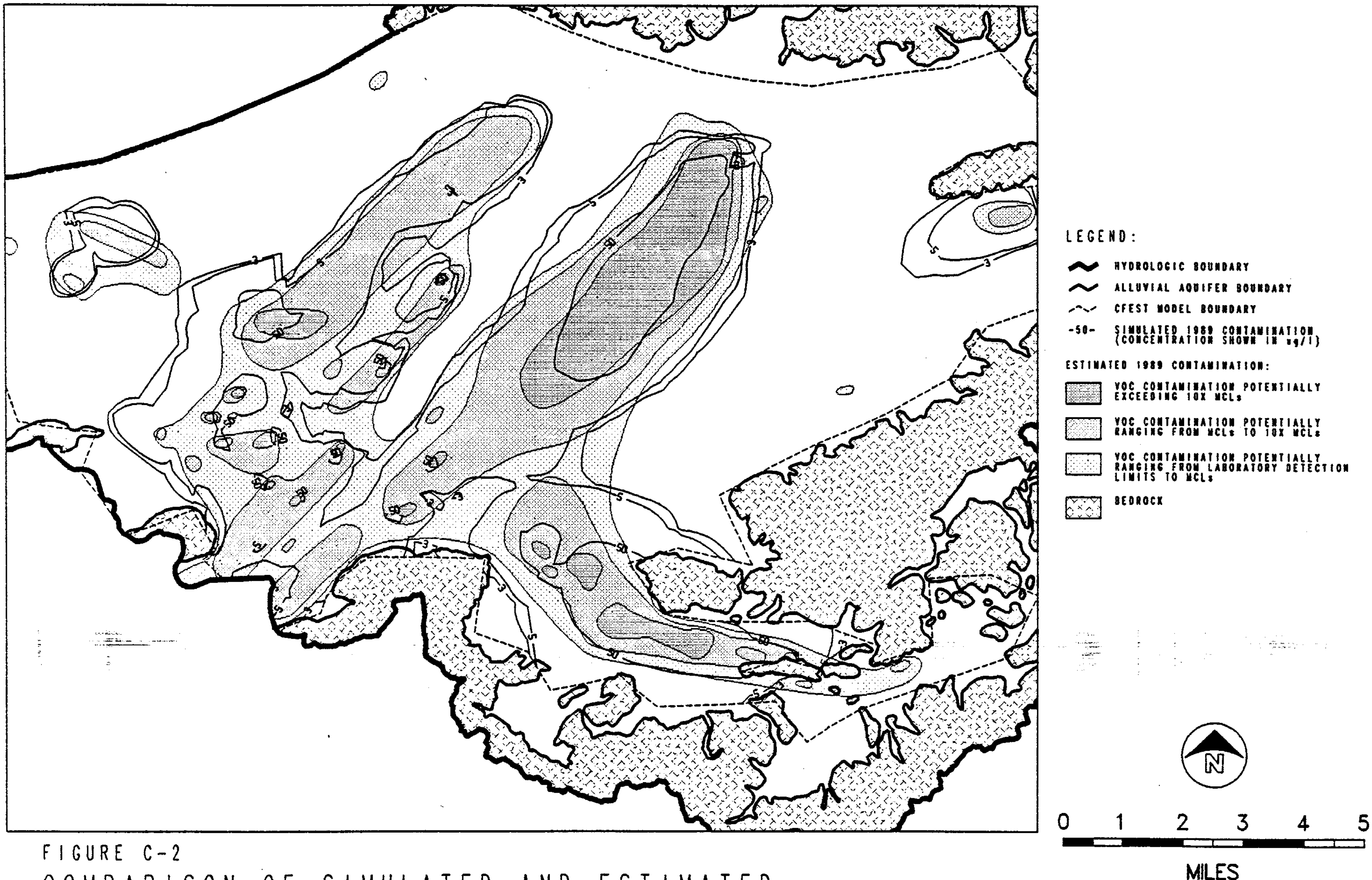

FIGURE C-2
COMPARISON OF SIMULATED AND ESTIMATED
1989 CONCENTRATIONS

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San Gabriel Basin

In addition to uncertainty in the nature of sources and initial conditions, subsurface contaminant transport is sensitive to small-scale heterogeneities (e.g., a small but laterally continuous gravel layer can dramatically increase the velocity of migrating contaminants). These variations in local-scale groundwater velocity contribute to the spreading or dispersion of contaminants that is often observed as they move downgradient. The transport model uses a parameter called dispersivity to simulate this effect. Sometimes, the further contaminants move, the more variations in local-scale velocities they encounter, and the more they tend to spread out or disperse. Consequently, dispersivity tends to be scale-dependent and varies as a function of how far the contaminants have traveled. Most transport models use constant dispersivities, estimated to get the best match between observed and simulated concentrations. However, because the timing and strengths of the sources are typically uncertain, so are fitted estimates of dispersivity. In the San Gabriel Basin, the locations, timing, and strengths of sources are so uncertain that the dispersivity was estimated based on the degree of variation observed in hydraulic conductivity measurements (EPA, 1989b), and from values reported in the literature to be about 300 feet.

The organic contaminants found in the basin are known to sorb or stick to organic matter in the aquifer. Because they spend some of their time attached to the organic matter, their overall velocity may be slower than the average groundwater velocity. This process, termed retardation, is represented in numerical models by a retardation coefficient which depends not only on the organic content of the aquifer, but also on the chemical properties of the specific contaminant. Unfortunately, no available measurements of the organic carbon content of the aquifer are available in the San Gabriel Basin. However, based on calculations using reasonable estimates for the type of aquifer materials observed in the San Gabriel Basin, the major contaminants in the basin might be expected to be retarded somewhere between not at all and by a factor of 2 to 3 (EPA, 1989b). Uncertainty in the actual groundwater velocities, however, makes this uncertainty small by comparison (EPA, 1989b). Therefore, to be conservative and to facilitate the analyses, the model represents the areas of contamination estimated in Figure 1-2 as only one contaminant which is not retarded by the sorption process.

To summarize, the difficulties associated with transport modeling suggest that model results cannot be used as an unqualified-predictive tool. Current practice typically requires some simplifying assumptions that may cause model results to differ from what happens in the far more complex natural environment. However, the transport model used in these analyses is based on reasonable estimates of uncertain parameters. EPA (1989b) presents an extensive evaluation of the effects of the uncertainty in model parameters on model results. The model results described below and in Section 2.0 appear reasonable and consistent with the scientific and engineering communities' understanding of transport phenomena. Consequently, it is a reasonable tool with which to analyze the effects of various real and hypothetical pumping scenarios. In Section 2.0, model results are described that estimate (1) the extent of contaminant migration between 1980 and 1989, (2) how much the purveyors' water quality management practices may have exacerbated the problem, and (3) the possible extent of contamination in 1999 and 2009 if no remedial action is taken. In the remainder of this appendix, the model is used to evaluate potential remedial actions.

C.3.0 ANALYSIS OF REPRESENTATIVE OPERABLE UNITS

To evaluate the relative effectiveness of each OU, it is compared to a reference (base case) simulation. The base case simulation is generated by using the calibrated three-dimensional numerical model described in detail in the Draft Report of Remedial Investigations (EPA, 1989b). Time-dependent heads are prescribed in the calibrated model along the Cucamonga and Sierra Madre faults, while constant-flow conditions are prescribed along the Raymond fault. No-flow conditions are prescribed along all other potential inflow boundaries within the model. In addition to the inflow from boundaries to the north including the Cucamonga, Sierra Madre, and Raymond faults, the model includes recharge in the form of precipitation, spreading ground infiltration, rivers, and applied water. Discharge occurs primarily through pumping and, to a lesser degree, as outflow through Whittier Narrows, along which time-dependent heads are prescribed.

The base case simulation is run for 39 quarter-years (approximately 10 years) beginning with the third quarter in 1977 and ending with the first quarter in 1987. Transient pumping and boundary conditions are prescribed throughout the 39 quarters. The base case simulation assumes that all time-dependent boundary conditions for the next 39 quarters of time are best represented by those prescribed for the previous 39 quarters. Therefore, time-dependent boundary conditions in the base case are the same as those prescribed in the calibrated simulation of the previous 10 years described in the Draft Report of Remedial Investigations (EPA, 1989b). Initial conditions in the base case model represent the most current levels of contamination throughout the basin.

Since OU performance is evaluated completely in terms of comparison between the base case simulation and a simulation modified to reflect OU pumping, care was taken to assure consistency in every other aspect of the two simulations. In addition, parameters that might introduce a degree of bias and uncertainty were avoided. For example, the large uncertainty associated with the introduction of sources of contamination, generally required in simulations of long periods of time, is removed in these simulations. Additionally, by limiting simulations to only one 10-year (39-quarter) period, the cumulative potential error in assuming that future pumping will be similar to historical pumping is minimized. Within a 10-year period, migration of the position of the upgradient margins of individual zones of contamination, at which the presence of sources is most critical, does generally not play an important role in OU performance.

To simulate each OU, only modifications to pumping data are required. The general procedure followed in changing production data is to increase production at new or existing wells within each OU to their capacity or a specific production rate. To better evaluate the effects of the OUs relative to the base case, net production is not changed. Wells downgradient, closest to the new production wells, are turned off first; and with increasing distance are turned off or reduced until the OU production demand is met. However, because production downgradient does not always meet OU production, the net production is balanced by turning off or reducing the production of wells upgradient. In some cases, OU production cannot be met by the surrounding production; and OU production must be reduced to meet the production removed from the available downgradient and upgradient wells. In general, downgradient production in one or two quarters each year balances the desired OU production. However, in other quarters, it fails to meet recommended production. The representative subset of OUs described in Section 5.0 is listed in Table C-1. Figures C-3 and C-4 illustrate initial (base case) VOC concentrations and the 1986 potentiometric surface respectively. The potentiometric map is presented as a tool for interpreting groundwater flow directions and will be referred to in the sections that follow.

Table C-1
REPRESENTATIVE SUBSET OF OPERABLE UNITS

Operable Unit	Primary Objective of Operable Unit
1E	Manage Contaminant Migration
2J	Manage Contaminant Migration
2BCFK	Contaminant Removal
4K	Manage Contaminant Migration
5TUV	Contaminant Removal
5CDGFIJ	Contaminant Removal
5W	Protect Groundwater Resource
6AB	Water Supply

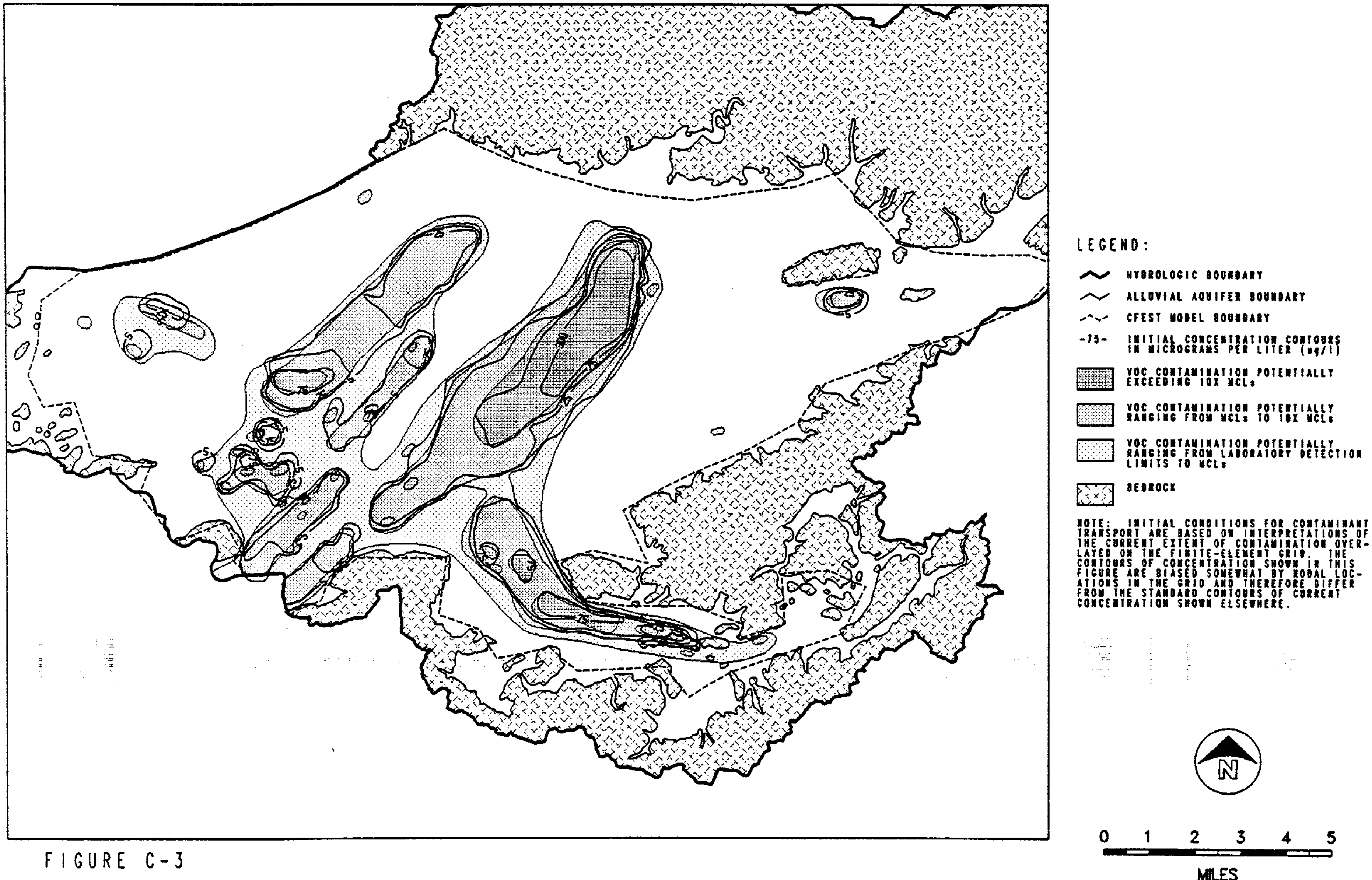

FIGURE C-3
INITIAL CONCENTRATION IN CONTAMINANT TRANSPORT MODEL

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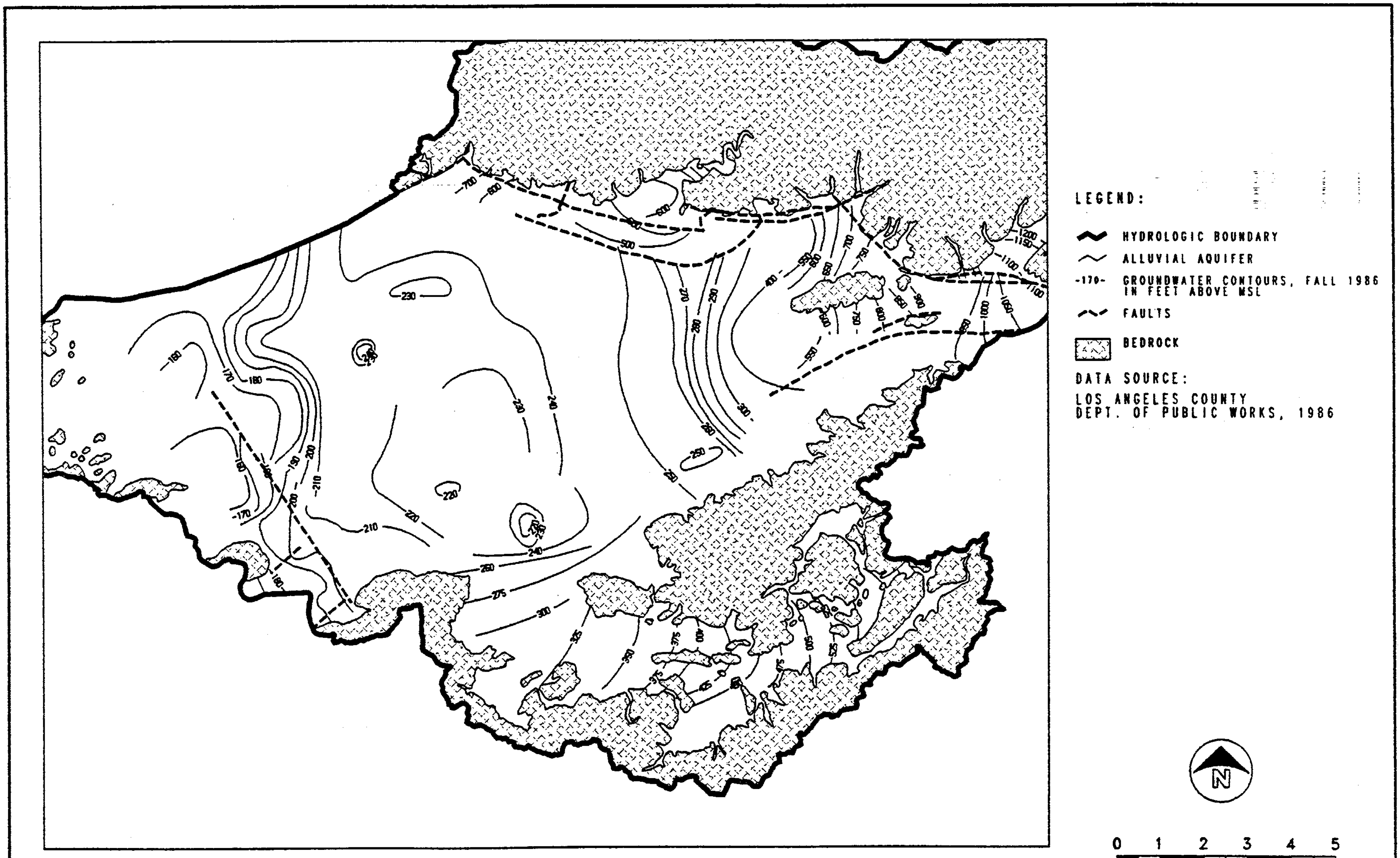

FIGURE C-4

POTENTIOMETRIC SURFACE, FALL 1986

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San Gabriel Basin

Wells at which pumping is reduced or eliminated are listed for the eight OUs evaluated in Table C-2. Total production rates simulated for each of the eight OUs are listed in Table C-3. The production recommended for OU wells, discussed in detail in the following sections (and illustrated by the flat lines in Figures C-5, C-9, C-13, C-15, C-17, C-25, C-29, and C-33), is typically both higher and lower at different times than the cumulative demand of the wells at which production is reduced or eliminated. In the actual implementation of these OUs, it is envisioned that during periods in which demand exceeds that available from the OU wells, the additional water will be produced from the wells shut down. (In most cases, the control of contaminant migration obtained through operation of the OU wells will allow continued, intermittent use of wells that would otherwise become too contaminated.) During periods in which the desired production exceeds demand, it may become desireable to continue production at the OU wells and dispose of the treated excess water in spreading grounds or river channels. However, it should be noted that intermittent extraction has been shown to increase the overall ability to remove contamination by continuously disrupting chemical gradients between contaminants in the groundwater and contaminants sorbed to matrix material.

The effectiveness of each OU in approaching its objective, as well as its effect on regional and local groundwater flow, is evaluated in the following discussions. The ability of the OUs to remove contamination is described in terms of comparisons of conditions after about 10 years with and without their implementation. Also included are qualitative evaluations of the potential effect of the OUs on the extent of nitrate contamination.

C.3.1 OPERABLE UNIT 1E

The primary objective of OU 1E is to manage the migration of the major zone of contamination in the northwest region of remedial investigation (RI) Area 1. As described in Appendix A, Operable Unit 1E consists of two existing wells pumped to a capacity totalling 1,184 acre-feet per quarter (ac-ft/qtr). These wells are located within the two MCL contours in Area 1 shown in Figure A-1. Production immediately downgradient and upgradient of the OU wells is reduced sufficiently to balance the increased OU production. Approximately 830 ac-ft/qtr (average for 39 quarters in Table C-3) is used in the actual OU simulation. Figure C-5 shows a graph of recommended production compared to the actual simulation production. Wells at which pumping is turned off or reduced in the OU 1E simulation are listed in Table C-2.

Contaminant levels from the numerical simulation after approximately 10 years (39 quarters) are illustrated in Figure C-6. Present conditions indicate two separate zones of contamination with levels as high as 25 micrograms per liter (ug/l) in the vicinity of OU 1E. The original zone of contamination (present conditions) shown in Figure C-3 is reduced significantly after 10 years in both the base case and OU 1E. The extent of the primary zone of contamination in

Table C-2 (1 of 2)
DECREASED PRODUCTION WELLS

OPERABLE UNITS

1E	2I	2BCFK	4K	5TUV	5CDGFIJ	5W	6AB
01900010	31903103	01902948	01903057	01901598	01903067	98000094	98000094
01900935	31900747	01902854	61900718	01901599	08000093	98000068	98000068
01901679	31900736	01940104	81902635	91901437	01901602	91901440	91901440
01900934	31900746	01901434	81902525	61900718	08000062	91901435	91901435
01900018	01900923	08000067	08000088	08000077	01901460	01900337	01900337
01900011	01900286	01903019	01900132	01902967	71903093	01901623	01901623
01900013	01900791	01900925	11900095	01903067	01902859	01901596	01901596
01900012	01900792	01900514	01901749	01903057	01902119	08000077	08000077
01900015	01900725	01900515	08000071	08000093	08000095	01902760	01902760
01900014	01900918	01900016	01901747	01901602	01901598	01902519	01902763
01902789	01902665	01901669	01901746	08000062	08000069	01902971	01902519
01903059	01903033	01900918	08000089	01901460	01901600	08000097	01903067
01901671	01902372	01903137	01902579	71903093	01902356	01903072	08000093
01902979	01902373	01901693	01901745	01902859	01900027	01902949	01901602
01902785	01902690	01900923	01902790	01902119	01900028	01902582	
01900017	01902144	01902867	08000027	08000095	01900032	08000096	
01900547	01900454	01900791	01900052	08000069	08000067	01902581	
	01900513	01900792	08000028	01901600	01902971	08000078	
	01900455	01900725	01900094	01902971	01902519	01902950	
	01900453	31903103	08000004	01902519	01902763	01902951	
	01902818	31900747	41900745	01902863	01900337	01903081	
	01900512	31900736	41902713	01900337	01901623	01901181	
	01900457	31900746	01900331	01901623	01901596	08000100	
	01900510	01902665	41900739	01901596	08000077	01903057	
	01900511	01903033	48000083	01902760	01902760	01901183	
	01900456	01902372	01903084	98000094	98000094	01901182	
	11900344	01902373	01902529	98000068	98000068	01901627	
	01903092	01902690	01900332	91901440	91901440	91901437	
	21900344	01902664	08000097	91901435	91901435	61900718	
	01900458	01902034	01903072	01901612	01903081	01902967	
	01902666	28000065	01902949	01903081	01901181		

Table C-2 (2 of 2)
DECREASED PRODUCTION WELLS

OPERABLE UNITS

1E	2J	2BCFK	4K	5TUV	5CDGFIJ	5W	6AB
	01902663	21900749	01902582	01901181	08000100		
	01901441	21902857	08000096	08000100	01903057		
	01902787	01902027	01902581	01901183	01901183		
	01903137	01902924	08000078		01902920		
	01901055	01902791	01902950		01900363		
	08000012	01902077	01902951		01900364		
	01901693	01905078	01903081		01900365		
	01902424	01901493	01901181		01901618		
	01902020	01901492	08000100		01901606		
	01900457	01903006	0190118B3		41901605		
		01901692			11900038		
		01900920			08000070		
		01903062			01901493		
		01900355			01901492		
		08000048			01903006		
		11901508			18000002		
		01901015			11900729		
					11902946		
					18000081		
					01900106		
					01903062		
					01901612		
					01901599		
					91901437		
					01902967		
					08000075		

Table C-3
INCREASED PRODUCTION WELL RATES
(Acre-Feet/Quarter)

OPERABLE UNITS

1E	2I	2BCFK	4K	5TUV	5CDGFIJ	5W	6AB
740	3171	8656	2525	4242	9827	4040	1313
772	2177	6135	2525	4242	9178	3925	728
716	3600	9177	2525	4242	11307	4040	1313
664	3600	9454	2525	4242	11987	4040	1313
946	3390	7830	2525	4242	8244	3948	722
1076	2652	6206	2525	4242	7682	2967	360
490	3600	8692	2525	4242	11792	4040	1313
207	3600	8776	2525	4242	11846	4040	1313
793	3469	8883	2525	4242	9567	4040	732
825	3042	6654	2525	4242	9646	3680	374
716	3600	9828	2525	4242	11375	4040	1046
597	3600	9706	2525	4242	12011	4040	1313
944	3600	8775	2525	4242	9846	3637	1295
1059	3054	5486	2525	4242	7493	2540	821
518	3600	9190	2525	4242	11504	4040	1213
245	3600	8232	2525	4242	11717	4040	1313
909	3600	9553	2525	4242	8522	3642	1313
1102	3105	7295	2525	4242	7957	3085	1036
1009	3600	8727	2525	4242	12168	4040	1293
477	3600	10124	2525	4242	12720	4040	1313
1029	3600	8537	2525	4242	10535	3939	1054
1062	3301	7280	2525	4242	8347	2595	891
919	3600	9017	2525	4242	12270	4040	1212
583	3600	9353	2525	4242	12848	4040	1313
1055	3600	7203	2525	4242	10793	3706	1072
1070	3600	9151	2525	4242	12360	4040	1313
928	3600	9866	2525	4242	12959	4040	1313
492	3600	9218	2525	4242	12894	4040	1313
1091	3600	8579	2525	4242	12709	4040	1313
1152	3501	7199	2525	4242	11901	4040	1313
773	3600	9243	2525	4242	12897	4040	1313
634	3600	8938	2525	4242	13020	4040	1313
1141	3600	9541	2525	4242	13137	4040	484
1040	3600	8227	2525	4242	11830	4040	460
979	3600	9298	2525	4242	13140	4040	1264
794	3600	9097	2525	4242	13076	4040	1282
1069	3600	10062	2525	4242	12819	4040	813
1046	3547	8814	2525	4242	11818	3522	559
718	3600	9674	2525	4242	12735	4040	1027

Note: Each row represents the increased production rate per quarter of the indivdual OU for the 39 quarter simulation.

the northwestern region of Area 1 after almost 10 years, is about 0.25 square miles smaller in the OU simulation than in the base case. Differences in the extent of contamination as a result of base case pumping and extraction at OU 1E, indicated by different shading patterns, include a reduction of the contaminated zone by approximately 25 percent more than would otherwise occur in the northwestern portion of Area 1. Contaminant concentrations are reduced to approximately 5 ug/l near the northernmost OU well as indicated in Figure C-4. Contamination near the other OU well is reduced to below MCLs in both the base case and OU simulations.

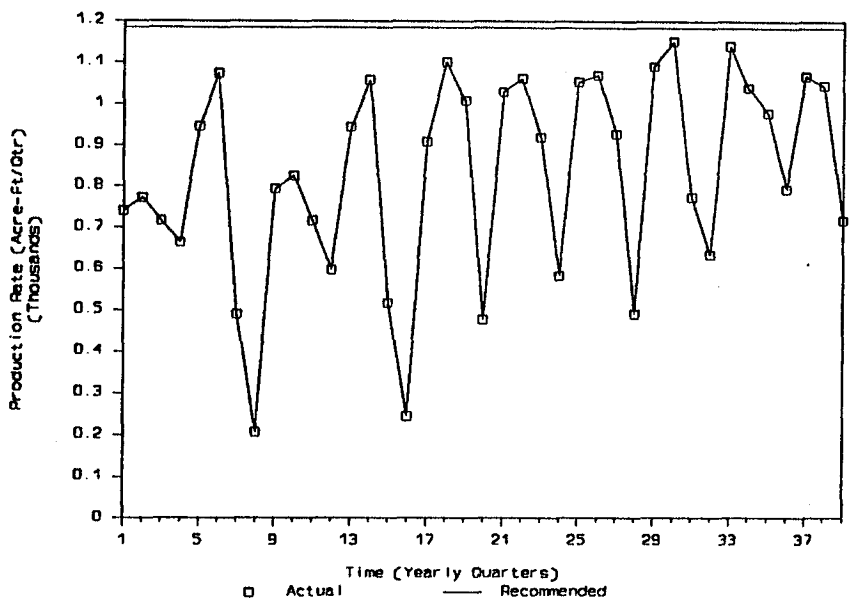

Figure C-5: OU 1E - Recommended vs Actual Production Rates

Regionally, the groundwater flow pattern does not reflect the production modifications made in OU 1E, as it flows in a southwesterly direction over much of Area 1 (Figure C-4). Towards the southwestern portion of Area 1, groundwater flows toward the northwest. Vectors representing groundwater flow velocities and directions for both the base case and OU simulations are shown in Figure C-7. Although regional patterns remain roughly the same, local flow directions are directed more toward the two OU wells than in the base case because of their relatively high production rates. This is particularly true in the area immediately west of the OU wells where groundwater flow is dominated by the effects of wells shut down in the OU simulations. It is clear in Figure C-7 that VOCs throughout this area are directed toward the OU wells.

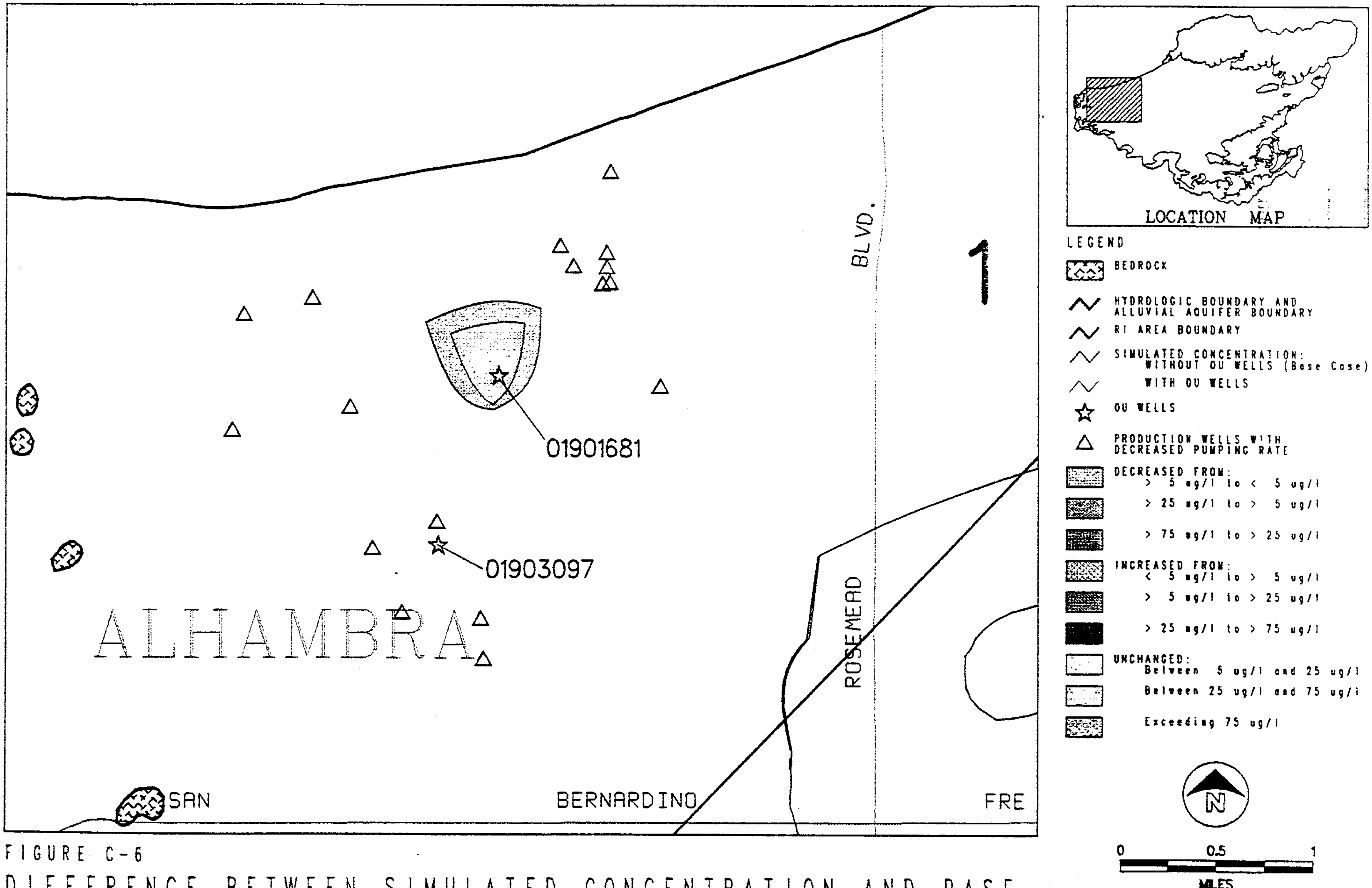

FIGURE C-6

DIFFERENCE BETWEEN SIMULATED CONCENTRATION AND BASE CASE CONCENTRATION AFTER 9.75 YEARS FOR OU1E

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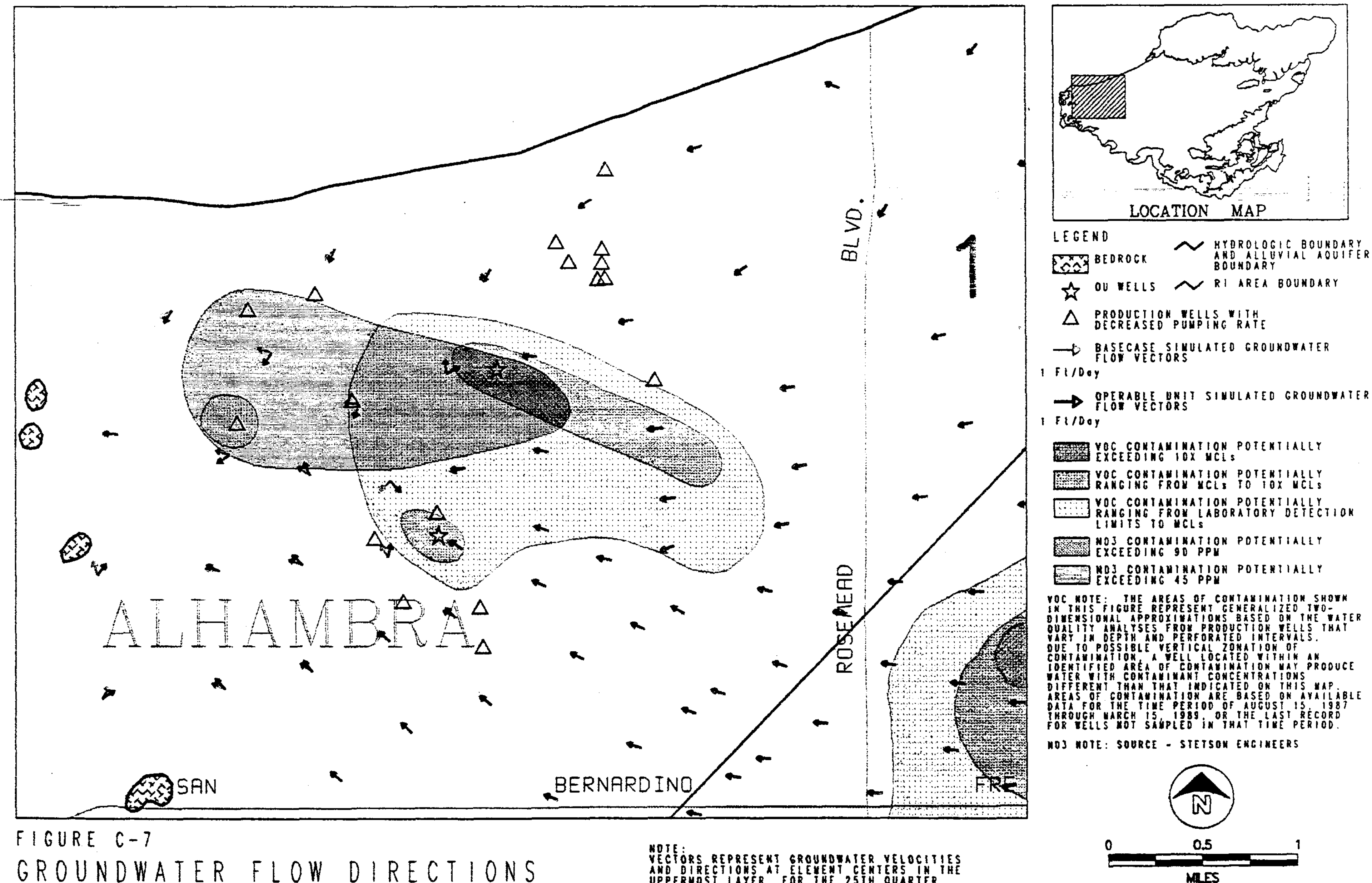

FIGURE C-7

GROUNDWATER FLOW DIRECTIONS WITH AND WITHOUT OU1E

NOTE:
VECTORS REPRESENT GROUNDWATER VELOCITIES AND DIRECTIONS AT ELEMENT CENTERS IN THE UPPERMOST LAYER, FOR THE 25TH QUARTER SIMULATED (FALL, 1983). VELOCITIES SHOWN ARE DARCY VELOCITIES.
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Also shown in Figure C-7 is the current interpreted extent of nitrate contamination above MCLs in the area. Nitrates occur in the area immediately west of the OU, within the zone in which groundwater flow directions are substantially altered. According to the vectors in Figure C-7, a little less than half of the nitrate contamination in the area will be deflected toward the OU wells. The rest will continue to migrate predominantly westerly, with some deflection toward the south. It does not appear that nitrates will represent a significant portion of the contaminants extracted at the OU wells. Unless residual nitrate in the area will continue to contribute to groundwater contamination, the extent of nitrate contamination in Area 1 should be considerably reduced through the operation of OU 1E.

Assuming no continuing sources of contamination, the total mass of contaminants removed after 39 quarters of operation of OU 1E is estimated to be 1,022 lb. Figure C-8 shows the amount of contamination removed as a function of time (39 quarters). The figure indicates that the quantity of contaminant removed decreases (as expected) as a function of time. Estimates of mass removal over time are highly speculative and completely dependent on assumptions regarding continuing sources of contamination. Even if primary sources at the surface are no longer present, it is very probable that residual sources in the subsurface will continue to contaminate groundwater for long periods of time (see Section 2.0). Unfortunately, in the absence of any data regarding the nature of these sources, and, as mentioned above, in light of the relatively short period simulated, continuing sources are not accounted for in this and the discussions that follow. Therefore, although decreases in the mass of contaminants removed at OU wells will eventually occur, predictions of the timing of these decreases are ill-founded. Nevertheless, it is useful to examine the results of the OU simulations with respect to estimates of contaminant removal rates to allow for comparison between different OUs. Accordingly, such estimates are included in this Appendix for comparative purposes.

In comparison to present conditions, OU 1E effectively reduces the overall a real extent of contamination by approximately 90 percent (about 0.25 square miles).

Levels of contamination decrease from 25 ug/l to below 5 ug/l near the northernmost OU well. The base case shows a similar pattern in the reduction of the extent and magnitude of contamination, albeit to a lesser extent. (As noted before, these simulations assume no continuing sources of contamination.)

C.3.2 OPERABLE UNIT 2J

Operable Unit 2J consists of three new wells with a combined production rate of 3,600 ac-ft/qtr. The objective of these OU wells is to manage the migration of the primary zone of contamination within Area 2 shown in Figure A-2b. The OU wells are located at the downgradient edge of the largest greater-than

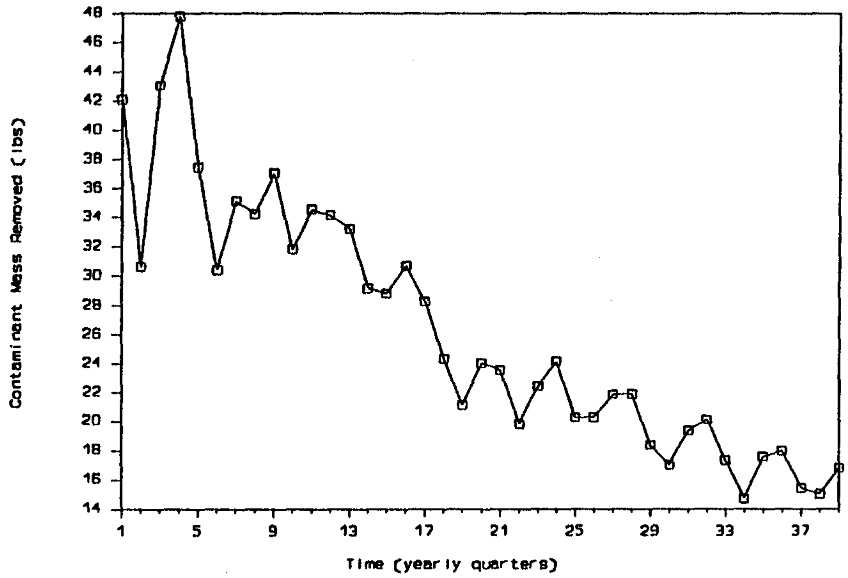

Figure C-8: OU 1E - Contaminant Mass Removed vs Time

MCL zone of contamination within Area 2. South of these wells are local zonesof higher concentrations (up to 300 ug/l). South of the main zone of contamination, there are several localized areas of high concentration within a 5 ug/l contour extending throughout most of the southern portion of Area 2. Because wells downgradient of the OU do not provide sufficient production to account for the desired increase in production at OU wells (Appendix A), OU production was reduced to meet the available downgradient production. The production at OU wells is approximately 3,460 ac-ft/qtr. Figure C-9 shows the desired OU production compared to the simulated OU production for the 39 quarters. Table C-3 shows the actual simulation production rates used in each OU as a function of time. Wells at which pumping is eliminated or reduced in the OU 2J simulation are listed in Table C-2.

Results of the OU 2J and base case simulations are compared in Figure C-10. There are two significant changes: (1) the areal extent and localized zones of higher contamination (i.e., 25 ug/l and greater) in the central portion of Area 2 are reduced by about 0.25 square miles, and (2) the areal extent of contamination in the southern portion of Area 2, downgradient of the OU 2J wells, increases about 1.1 square miles. In the central portion of Area 2, the 5 ug/l contour describing the extent of contamination after 10 years of OU 2J operation

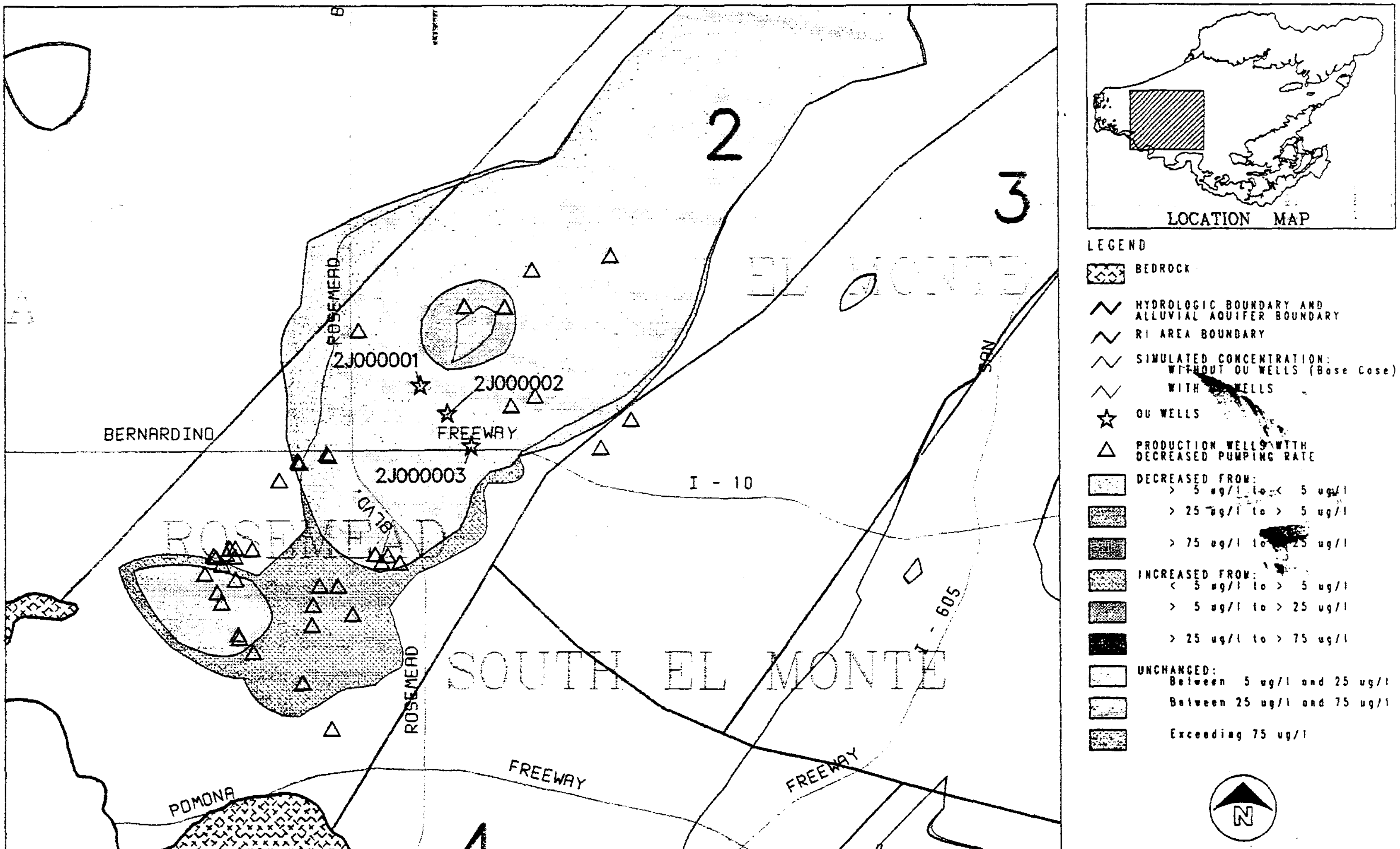

FIGURE C-10

DIFFERENCE BETWEEN SIMULATED CONCENTRATION AND BASE CASE CONCENTRATION AFTER 9.75 YEARS FOR OU2J

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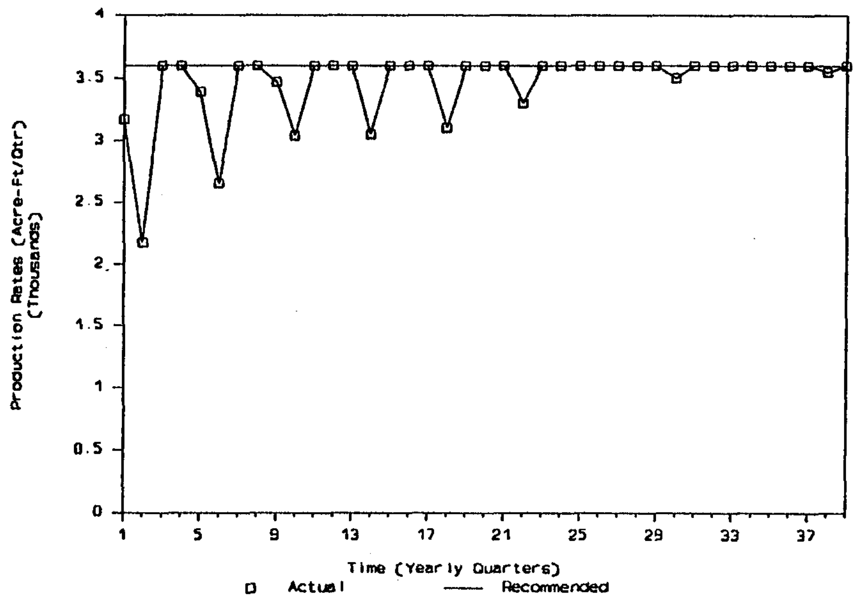

Figure C-9: OU 2J - Recommended vs Actual Production Rate

appears smaller than the base case extent by approximately 10 percent, whereas the 25 ug/l contour appears to be approximately 40 percent smaller in extent compared to the base case. In the southern portion, the 5 ug/l contour describing the base case extent of contamination is approximately 60 percent smaller than is the case after implementing the OU 2J wells.

The increase in a real extent of contamination in the southern portion of Area 2 is certainly affected by the shutdown of wells in this area. The influence of the three OU wells on downgradient contamination is limited because of the combined effects of water being preferentially drawn from the north of the wells, and the regional gradient being toward the southwest. However, in the central region of Area 2, the zone of contamination is more effectively reduced than in the base case because of the local increase in production around OU wells. Hydraulic conductivities decrease from 200 feet per day (ft/day) in the north of Area 2 to 25 ft/day in the south.

Vectors representing groundwater-flow conditions with and without OU 2J are shown in Figure C-11. The effects of the OU are slightly wider spread than was the case with OU 1E. The slight shifts in the extent of VOC contamination in Area 5, shown in Figure C-7, can be seen to result from slight increases in groundwater flow velocities at the western edge of the figure. Most of the changes to the groundwater system, however, occur within a few miles of the OU extraction wells. Areas affected the greatest are those south and southwest of the extraction wells in the vicinity of a large number of wells at which pumping was reduced or eliminated.

Regionally, OU groundwater flow patterns reflect some minor differences compared to the base case (Figure C-4). In Area 1 and the southern portion of Area 2, hydraulic heads are greater than base case heads as a result of reduced production downgradient. In the northern region of Area 2, heads are lower than base case heads because of the influence of OU production on upgradient regions. The difference in heads is less in Areas 3 and 5. Overall, the general trend of contaminant migration mirrors the regional groundwater direction toward the southwest moving partly into Area 1 and downward to the south in Area 2 (Figures C-3 and C-4). The northern edge of contamination migrates toward the south approximately 2 miles. Nitrate contamination above MCLs does not occur within any of the areas affected by this OU.

Under the simulation conditions, VOC contamination of 25 ug/l or greater appears to be completely removed from Area 2, except for the 25 ug/l zone in the center. The total mass of contaminants removed in OU 2J is estimated at 1,053 lb (see discussion of estimates of mass removal for OU 1E). This is based on the declining rate of contaminant removal shown in Figure C-12. Although in Figure C-10 it appears that higher concentrations of contaminants are removed, the extent of low-level contamination does not appear effectively addressed by this OU, as configured in this numerical simulation. The combined effect of changes to groundwater flow patterns, and the decreased pumping in the southern portion of Area 2, will probably not alleviate the lower contaminant concentrations (i.e., less than 25 ug/l) in the southern portion of the area. The objective of migration control of this OU is thus generally met in terms of controlling migration of high-level contamination (greater than 25 ug/l). However, contamination of lower levels is less affected, and, in fact, may spread at a greater rate as a result of implementing this OU as presently conceived. This illustrates the need to carefully plan and evaluate future OUs to minimize any adverse effects and obtain greater overall net benefits from remedial actions.

C.3.3 OPERABLE UNIT 2BCFK

The objective of OU 2BCFK is to utilize 1 new well and 14 existing wells to remove contamination within Area 2 at a recommended overall rate of 11,542 ac-ft/qtr. The OU wells are clustered in two locations within Area 2 (Appendix A): Clusters 2F and 2K are located within the main 25 ug/l zone of contamination near the downgradient margin, and Clusters 2B and 2C are in the same zone toward the northern margin (Figure A-2a). The wells in the south are located toward the upgradient end of a contaminated zone where VOC concentrations range up to 300 ug/l. Production rates in these wells range from 260 to 739 gallons per minute (gpm). The new production rate in

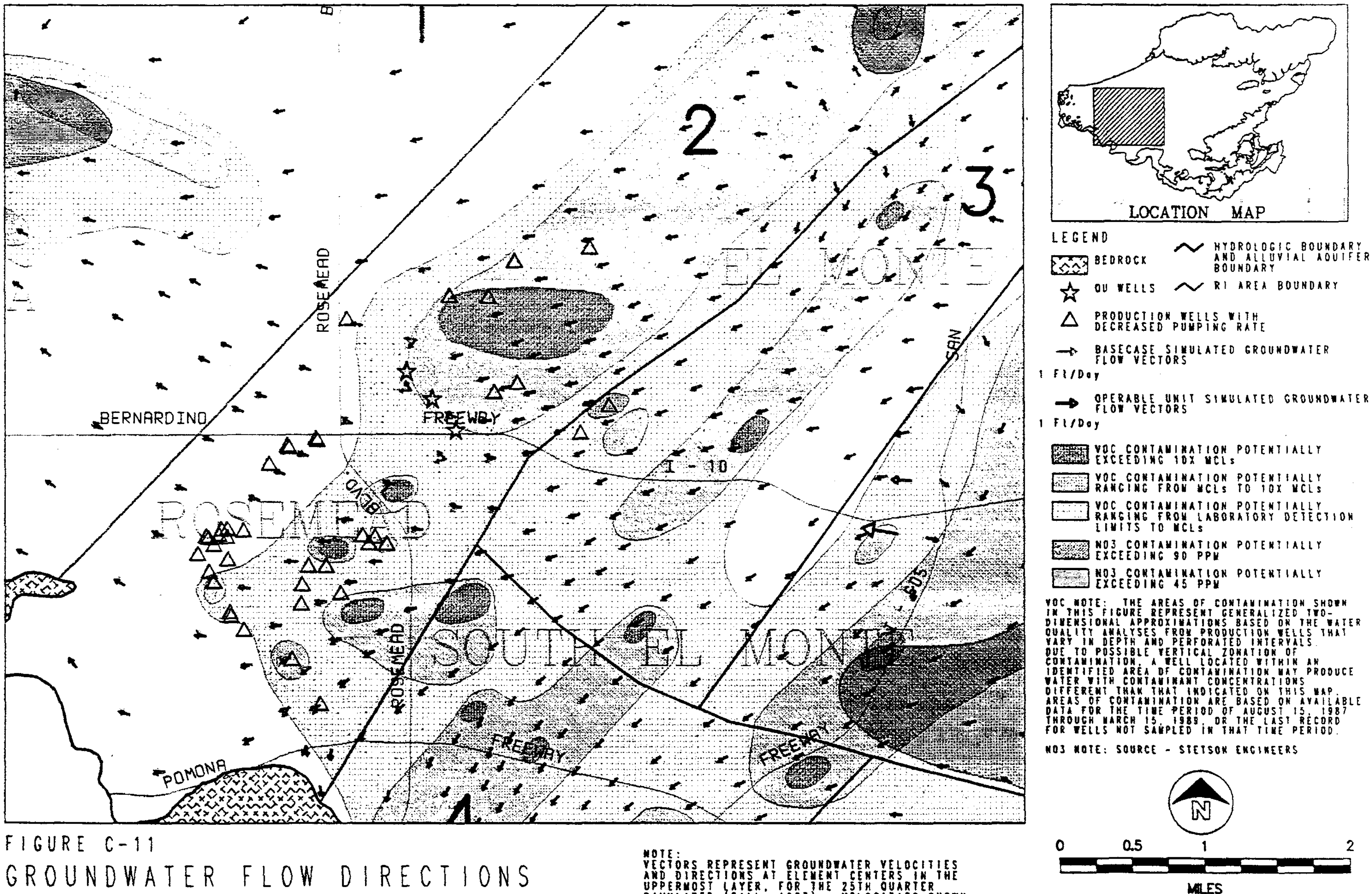

FIGURE C-11

GROUNDWATER FLOW DIRECTIONS WITH AND WITHOUT OU2J

NOTE:
VECTORS REPRESENT GROUNDWATER VELOCITIES AND DIRECTIONS AT ELEMENT CENTERS IN THE UPPERMOST LAYER, FOR THE 25TH QUARTER SIMULATED (FALL, 1983). VELOCITIES SHOWN ARE DARCY VELOCITIES.
(ACTUAL VELOCITY = DARCY VELOCITY/POROSITY)

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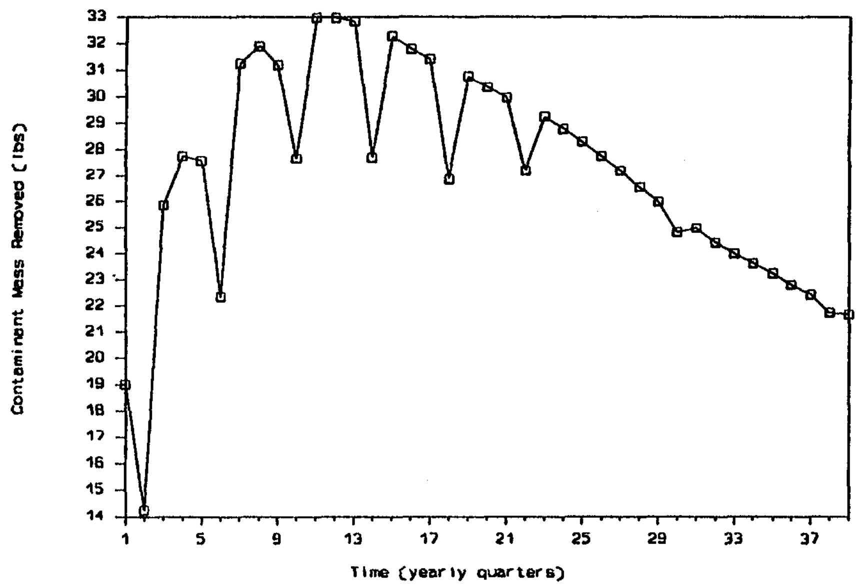

Figure C-12: OU 2J - Contaminant Mass Removed vs Time

these wells is 3,000 gpm for a combined total of 1,952 ac-ft/qtr. Production rates for wells in the north (2B and 2C) range from 360 to 3,843 gpm, with a total of 9,589 ac-ft/qtr.

South of the main zone of contamination, there are several localized areas of relatively high contamination. Similar to OU 2J, wells downgradient of the OU wells do not provide sufficient production to account for the total desired increase in OU wells; recommended production is thus reduced to meet available downgradient production. To further meet production requirements, large production wells located upgradient and to the east and west of the OU wells are also turned off. The OU production rates used in the simulation total approximately 8,600 ac-ft/qtr (average for 39 quarters in Table C-3). Figure C-13 shows the recommended OU production compared to the actual simulation OU production for the 39 quarters. Wells at which pumping is turned off or reduced in the OU 2BCFK simulation are listed in Table C-2.

Results of the 2BCFK and base case simulations are compared in Figure C-14 and, like OU 2J, indicate two significant differences. First, in the central portion of Area 2, the areal extent of localized zones with concentrations in excess of 25 ug/l are reduced by approximately 1.4 square miles. Second, the areal extent of contamination greater than 5 ug/l in the southern portion of Area 2, downgradient of the OU 2BCFK wells, increases by about 1.5 square miles. In the central portion of Area 2, the area prescribed by the 5 ug/l contour around

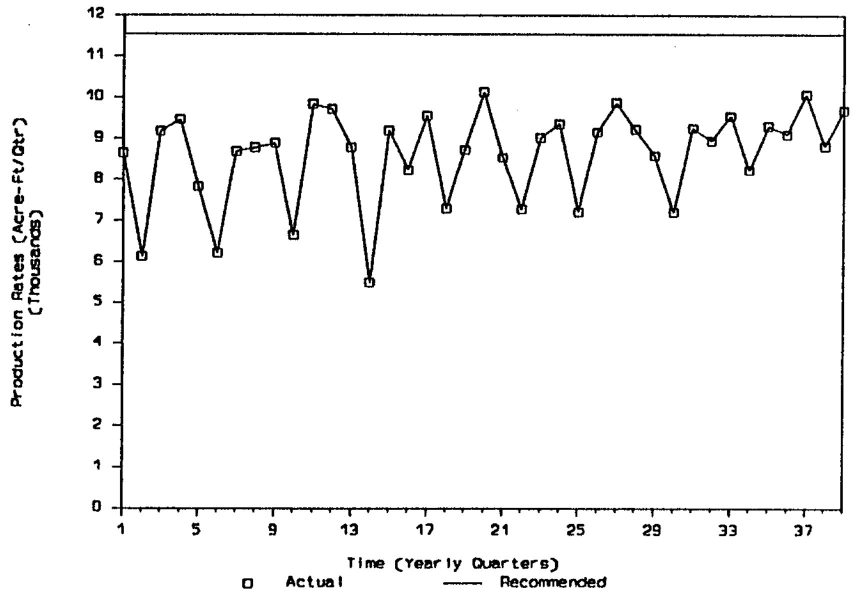

Figure C-13: OU 2BCFK - Recommended vs Actual Production Rate

OU 2BCFK is about 15 percent smaller than that of the base case. However, the area surrounded by the 25 ug/l contour contained within this 5 ug/l contour increases, and is approximately 40 percent larger in extent than in the base case. Based on the position of the 5 ug/l contour in the southern portion of Area 2, the base case extent of contamination is approximately 70 percent smaller than that of the OU 2BCFK simulation.

Figure C-14 shows the increase in areal extent of the contaminated zone in the south in the OU 2BCFK simulation. This increase is greater than that produced in the OU 2J simulation, which is likely a reflection of the fact that more downgradient wells are turned off for OU 2BCFK than for OU 2J, and much less groundwater is extracted in the southern region of Area 2. Groundwater in southern Area 2 is not affected by the OU wells upgradient for several reasons: (1) hydraulic conductivity decreases from 200 ft/day in the north of Area 2 to 25 ft/day in the south and therefore causes water to be preferentially drawn from the north of Area 2 and (2) the regional direction of groundwater flow is towards the southwest which also lessens the effect of upgradient wells on the southern region of Area 2. The OU production in the southern wells (2F and 2K), which is approximately 2,000 ac-ft/qtr less than the OU 2J wells in about the same area, also causes less of an influence upgradient.

As indicated in Figure C-14, in the central portion of Area 2, the zone of contamination is drawn in more effectively around the OU wells than in the base case. This results from increasing production at Clusters 2B and 2C by about 6,000 to 7,000 ac-ft/qtr. However, the 25 ug/l contour in the central region appears larger than in the base case because the 2F and 2K clusters are located just upgradient of this contamination. This is also partially the result of lowering the desired levels of production in the OU by about 70 percent.

Regionally, water levels drop over much of the basin. The effect of the OU is regional and is observed in all areas except 7 because OU 2BCFK is located within a zone of relatively high hydraulic conductivity and because of the large production rates of the OU wells (Figure C-4). However, relatively minor effects are observed in the northern region of Area 5 because hydraulic gradients in that area are large enough to overcome the effects of the OU. Wells with increased production (represented by stars in Figure C-14) are listed in Table C-4.

Vectors representing the directions and magnitudes of groundwater flow are compared for the basecase and OU simulations in Figure C-15. The regional effects are apparent, particularly within a few miles of the northern and southern groups of OU wells. Most of the changes in flow directions occur downgradient of the OU extraction wells as water is deflected into the large cones of depressions surrounding OU wells. Flow directions are also affected wherever wells have been turned off. This can be seen in northern Area 3, southern Area 2, and even in the eastern portion of Area 1. None of the areas affected by OU pumping contain significant nitrate contamination. However, one of the wells turned off, in southwestern Area 3 contains nitrate contamination above 45 milligrams per liter (mg/l). If the zone is as small as interpreted in Figure C-11, nitrates will represent a very small fraction of the contaminants extracted at the OU wells.

The modeling results suggest that, in the absence of continuing sources, VOC contamination greater than 25 ug/l within Area 2 may be completely removed within 15 years. The declining rate of contaminant removal is shown in Figure C-16. The primary reason for the sharp decline in contaminants removed is probably related to the apparently complete removal of detectable VOCs from the area surrounding the northern clusters of wells in OU 2BCFK. Whether or not this will actually occur is very much a function of the location and extent of residual contamination in the area: if residual contamination in the vadose zone or as dense nonaqueous phase liquids (DNAPLs) in the aquifer is present and continues to provide a source of contaminants to the groundwater, it is unlikely that the upgradient boundary of contamination will have receded after ten years as shown in Figure C-14. The uncertainty of mass removed over time is discussed more fully in the OU 1E evaluation (Section C.3.1).

Table C-4
INCREASED PRODUCTION WELLS

OPERABLE UNITS

1E	2J	2BCFK	4K	5TUV	5CDGFIJ	5W	6AB
01901681	2J000001	2B000276	4K000001	5T000001	01900034	5W000001	01901617
01903097	2J000002	01900420	4K000002	5U000001	08000060	5W000002	31902820
	2J000003	01902019	4K000003	5V000001	01902169	5W000003	31902819
		01902017			01900883	5W000004	01901625
		01900419			01900882		01901621
		01902018			01900885		
		01900417			01900035		
		01901014			01900031		
		01900418			71900721		
		01901013			08000039		
		01900356			71903093		
		01902032			51902858		
		01902031			51902947		
		01901695					
		01902020					

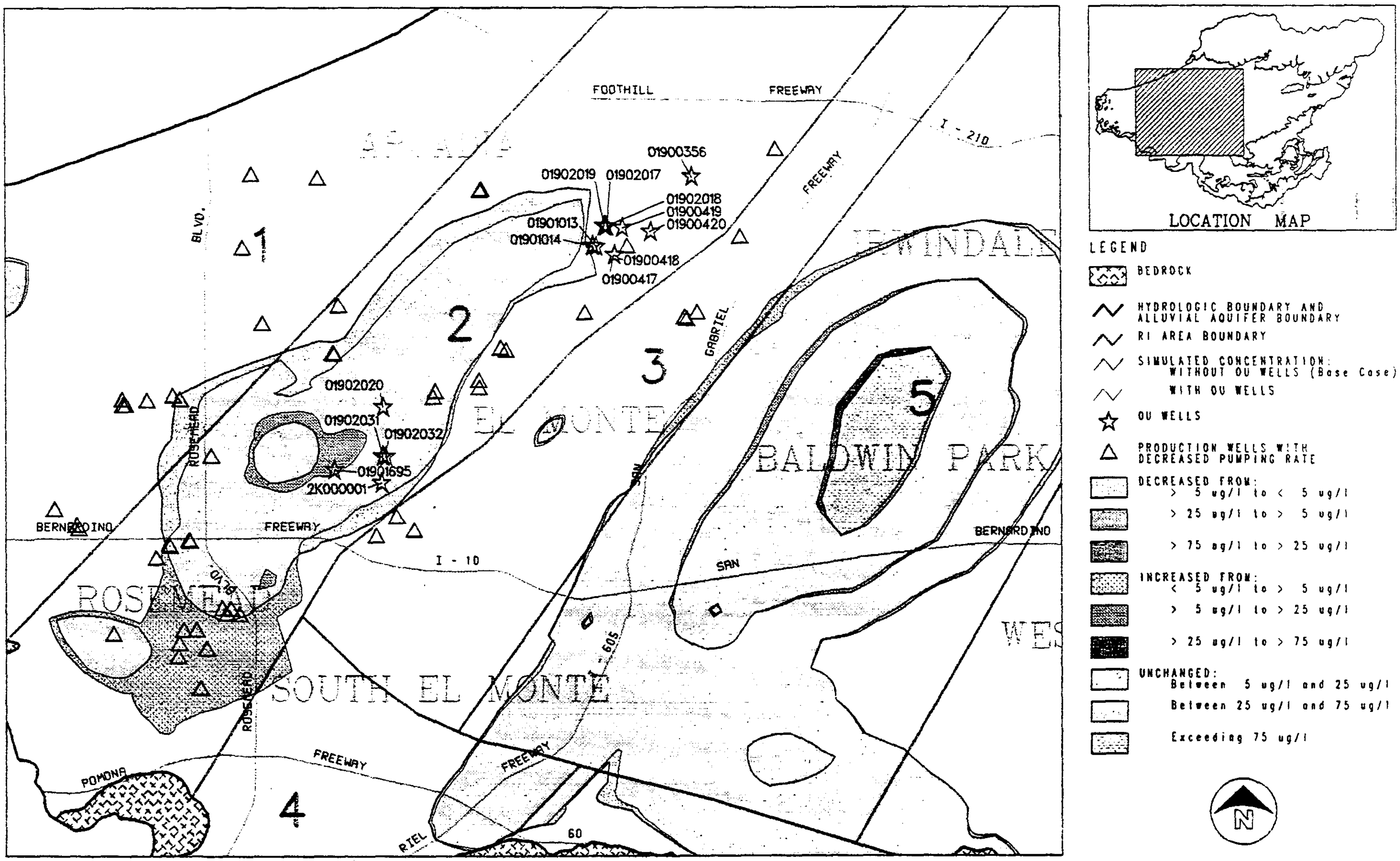

FIGURE C-14

DIFFERENCE BETWEEN SIMULATED CONCENTRATION AND BASE CASE CONCENTRATION AFTER 9.75 YEARS FOR OU2BCFK

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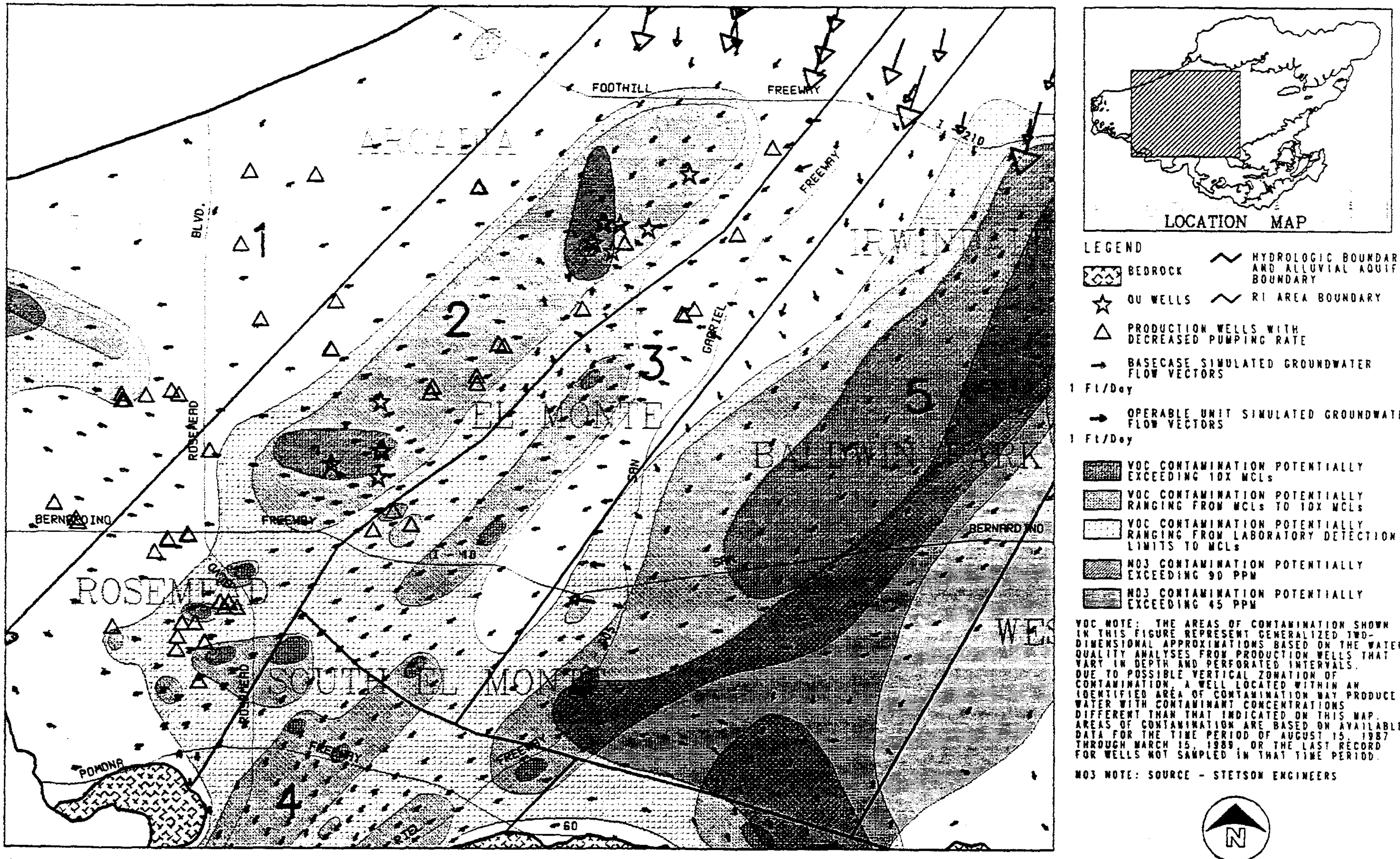

0 0.5 1 2
MILES

FIGURE C-15

GROUNDWATER FLOW DIRECTIONS
WITH AND WITHOUT OU2BCFK

NOTE:
VECTORS REPRESENT GROUNDWATER VELOCITIES AND DIRECTIONS AT ELEMENT CENTERS IN THE UPPERMOST LAYER, FOR THE 25TH QUARTER SIMULATED (FALL, 1983). VELOCITIES SHOWN ARE DARCY VELOCITIES.
(ACTUAL VELOCITY = DARCY VELOCITY/POROSITY)

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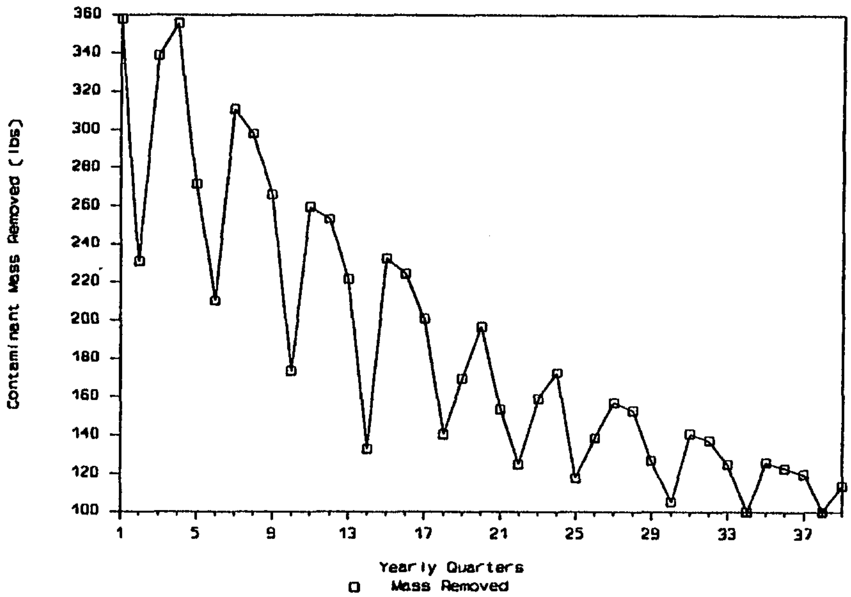

Figure C-16: OU 2BCFK - Contaminant Mass Removed vs Time

Nevertheless, the combined effects of changes in the regional gradient, and the decreased pumping in the southern portion of Area 2 will probably not remove contamination of lesser concentrations (i.e., 5 ug/l to 25 ug/l) in the southern portion of the area. Compared to OU 2J, the objective of OU 2BCFK of removing contaminants can apparently be achieved in a relatively cost-effective manner as with only three times more production, OU 2BCFK removes seven times the amount of contamination that 2J does. However, OU 2BCFK, as conceived in this simulation, appears less effective at controlling migration to the south.

C.3.4 OPERABLE UNIT 4K

The objective of OU 4K is to manage the migration of contaminants from Area 5 into Area 4. About 2,525 ac-ft/qtr (Table C-3) will be extracted by the three new wells as shown in Figures C-17 and C-18. The OU wells are clustered southwest of the main above-MCL contour that extends from the northern region of Area 5 into the northeastern corner of Area 4. As seen in Figure A-4a, several zones of contamination are present in Area 4. One zone above MCLs is located in the northeastern corner of Area 4. Production at surrounding wells can be decreased sufficiently to meet the extraction rates recommended for this OU in Appendix A. The OU production rate recommended in Appendix A of approximately 2,500 ac-ft/qtr equals the actual simulated OU production for the 39 quarters (Figure C-17). Wells at which

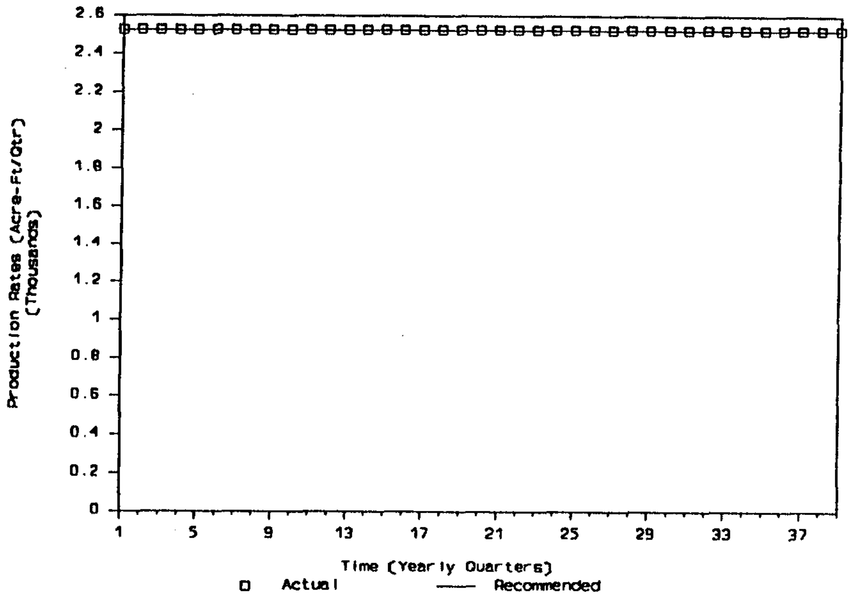

Figure C-17: OU 4K - Recommended vs Actual Production Rate

pumping is turned off or reduced in the OU 4K simulation are listed in Table C-2.

The major zone of contamination above 5 ug/l in Area 5 migrates approximately 1 to 2 miles toward the south, at both its northern and southern extent as shown in Figure C-18. Compared to the base case, at its southern extent, this zone appears to have migrated southeast and increased in size by approximately 5 percent (or about 0.26 square miles) in Area 6. On the other hand, in the southwest toward Whittier Narrows, the extent of contamination is reduced by 5 to 10 percent (or about 0.2 square miles). Currently, these parts of Areas 4 and 6 do not appear to be contaminated. The OU simulation results suggest that contamination migrating southward from areas upgradient of the OU has been entirely removed from Area 4, except for 2 small isolated zones of 5 ug/l contamination, after 39 quarters. In the base case simulation, substantially more contamination remains in this southern area of Area 4 after 39 quarters.

The migration of contaminants from Area 5 appears not to have been effectively stopped by the OU wells in Area 4, suggesting that production rates at the OU wells are insufficient. Actions intended to control migration require a particularly high level of remedial investigation to adequately design screening intervals and pumping rates on the basis of the vertical extent of contamination. In the numerical model, the vertical location of contaminants is highly generalized. With the appropriate data, an actual OU, designed to selectively

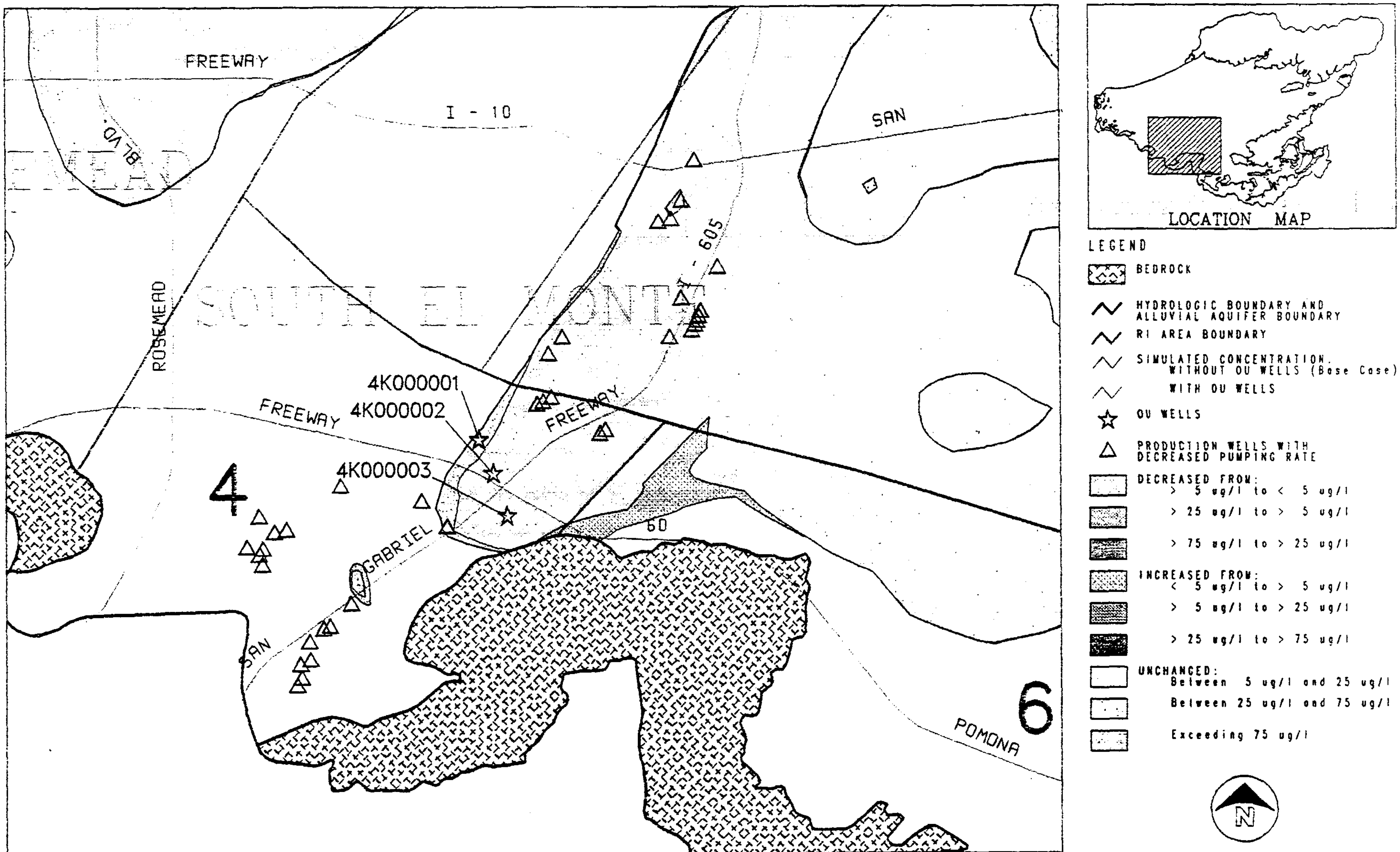

FIGURE C-18

DIFFERENCE BETWEEN SIMULATED CONCENTRATION AND BASE CASE CONCENTRATION AFTER 9.75 YEARS FOR OU4K

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extract from discrete vertical intervals, may be far more effective at controlling migration than is implied by this analysis.

Figure C-19 shows a comparison of groundwater flow directions and magnitudes for the OU and base case simulations. As before, the primary areas affected by OU pumping are downgradient of the OU, and in the vicinity of wells turned off. The potentiometric surface appears to be depressed substantially south of the extraction wells as shown by the decrease in groundwater velocities toward Whittier Narrows. In Area 5, although production is decreased at a large number of wells, the overall effect of 4K pumping appears negligible. No areas of significant nitrate contamination above MCLs appear affected by OU 4K. Nevertheless, the presence of nitrate contamination above MCLs a little over a mile upgradient of the OU wells suggests that it may be expected to reach their zone of influence well within 10 years. Overall, the general direction of groundwater flow does not vary significantly, either regionally or locally.

The total mass of contaminants removed in OU 4K is estimated at 1,092 lb. Figure C-20 shows that the rate of removal rises rapidly within the first 2 years and then, in the absence of continuing sources of contamination, slowly decreases. This is a result of the relatively rapid withdrawal of the higher levels contamination (i.e., 25 ug/l and higher) in the region immediately northeast of the OU wells.

Contamination in the southern region of Area 4 decreases primarily as a result of the decrease in downgradient production rates. Because of the increased heads in this area and the time-dependent boundary condition imposed at Whittier Narrows, groundwater outflow through Whittier Narrows is increased relative to the base case. Thus, again, the simulated effects are largely imposed by assumptions inherent to the numerical model. Hydraulic conductivities are relatively high (100 ft/day) through Whittier Narrows, which enhances the already rapid transport of contaminants through the area.

C.3.5 OPERABLE UNIT 5TUV

Operable unit 5TUV consists of three new wells producing 4,242 ac-ft/qtr. The objective of OU 5TUV is to remove the contamination within Area 5 shown in Figure A-5c. Each well extracts 1,400 ac-ft/qtr. The OU wells are located in a north-to-south line within the main zone exceeding MCLs in Area 5. This zone of contamination extends approximately 2 miles from the northern boundary to just within Area 4. In the southeastern portion of Area 5, a different zone of contamination above MCLs extends into Area 6, as shown in Figure C-3. Wells turned off downgradient of the OU wells meet the 4,200 ac-ft/qtr increase in OU production; no additional upgradient reduction in production is required (Figure C-21). The simulated OU production rate of approximately 4,200 ac-ft/qtr for the 39 quarters is equal to the rate recommended in Appendix A.

Wells at which pumping is turned off or reduced in the OU 5TUV simulation are listed in Table C-2.

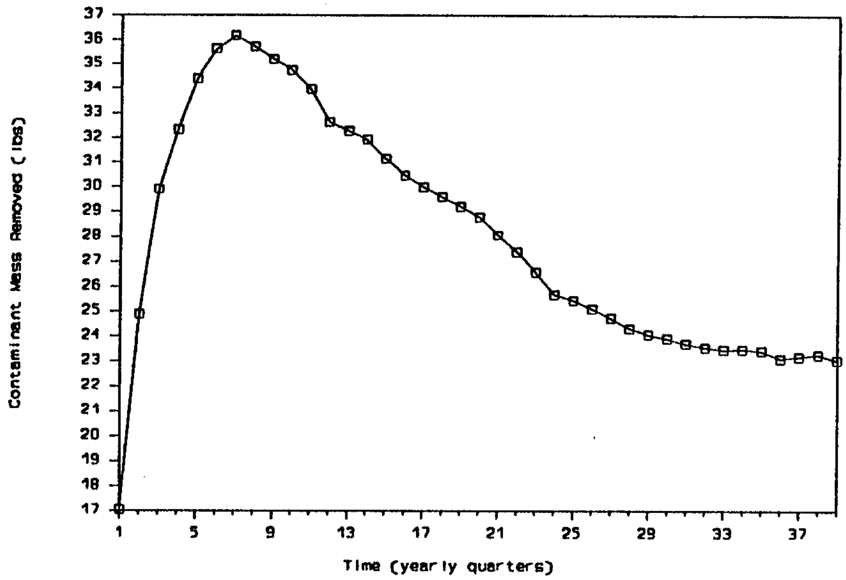

Figure C-20: OU 4K - Contaminant Mass Removed vs Time

After 10 years, the major zone of contamination in Area 5 migrates on the order of 1 to 2 miles toward the south from its present location, as shown in Figure C-22. At its southern extent, this zone migrates to the southeast, into Area 6, and southwest, toward Whittier Narrows (Area 4).

Results from the OU 5TUV and base case simulations are compared in Figure C-22. In general, zones contaminated above 5 ug/l and 25 ug/l are reduced by approximately 5 to 10 percent within the north end of the main zone of contamination in Area 5. The area above 25 ug/l in the southeastern corner of Area 5, which results from the migration of contaminants from Area 6, is reduced by approximately 10 to 15 percent in comparison to the base case. Areally, these percentages correspond to a total reduction in the extent of all zones of contamination by about 1.8 square miles after 10 years. Toward the south, however, the area above 5 ug/l in the OU 5TUV simulation, also associated with contamination in Area 6, is 5 percent greater (increases by less than 0.4 square miles) than in the base case.

Contamination in the OU simulation is substantially reduced because of the change in groundwater flow directions toward the OU wells in the center of Area 5. These wells also represent a significant increase in production relative

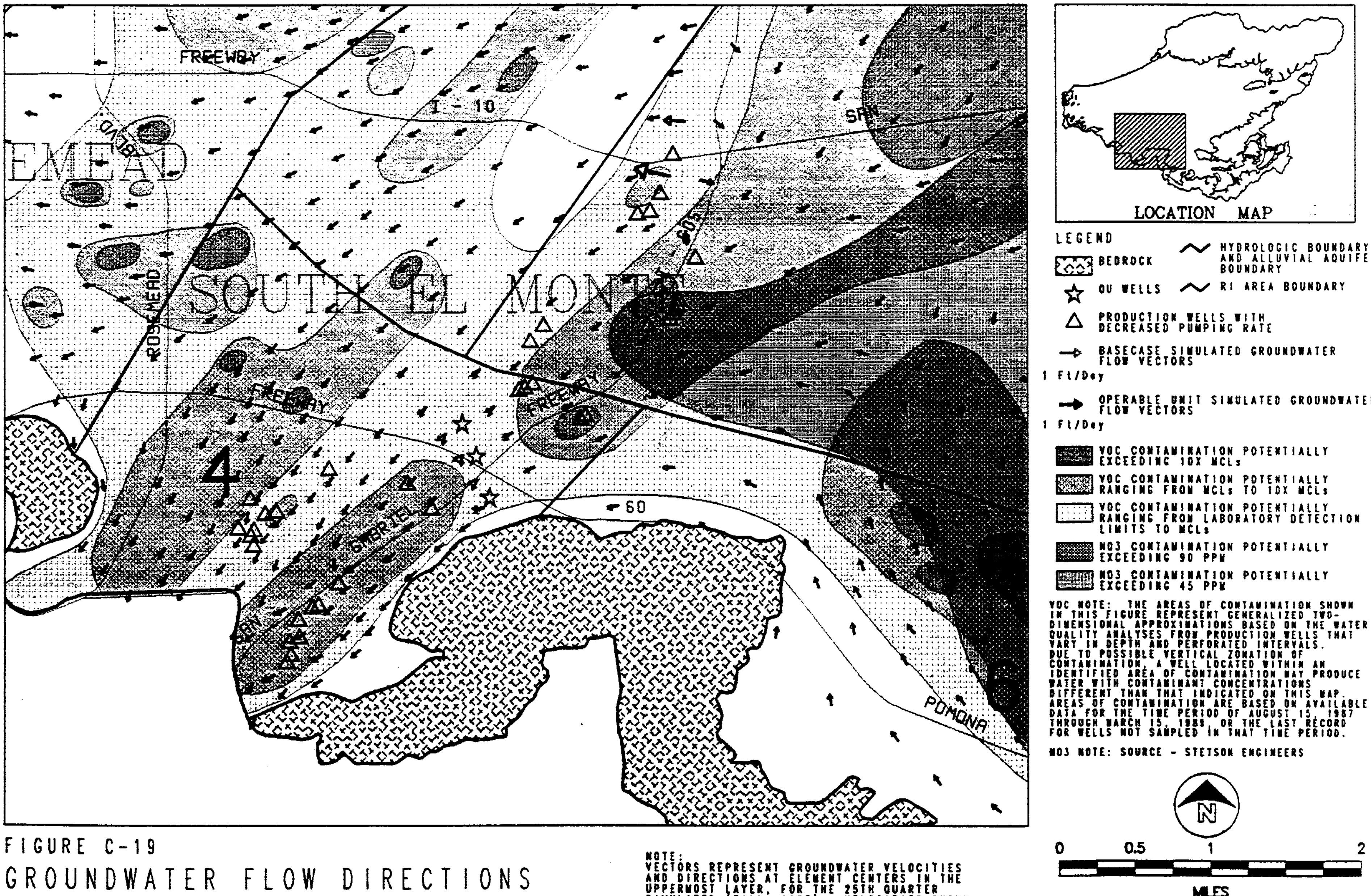

FIGURE C-19

GROUNDWATER FLOW DIRECTIONS WITH AND WITHOUT OU4K

NOTE:
VECTORS REPRESENT GROUNDWATER VELOCITIES AND DIRECTIONS AT ELEMENT CENTERS IN THE UPPERMOST LAYER, FOR THE 25TH QUARTER SIMULATED (FALL, 1983). VELOCITIES SHOWN ARE DARCY VELOCITIES.
(ACTUAL VELOCITY = DARCY VELOCITY/POROSITY)

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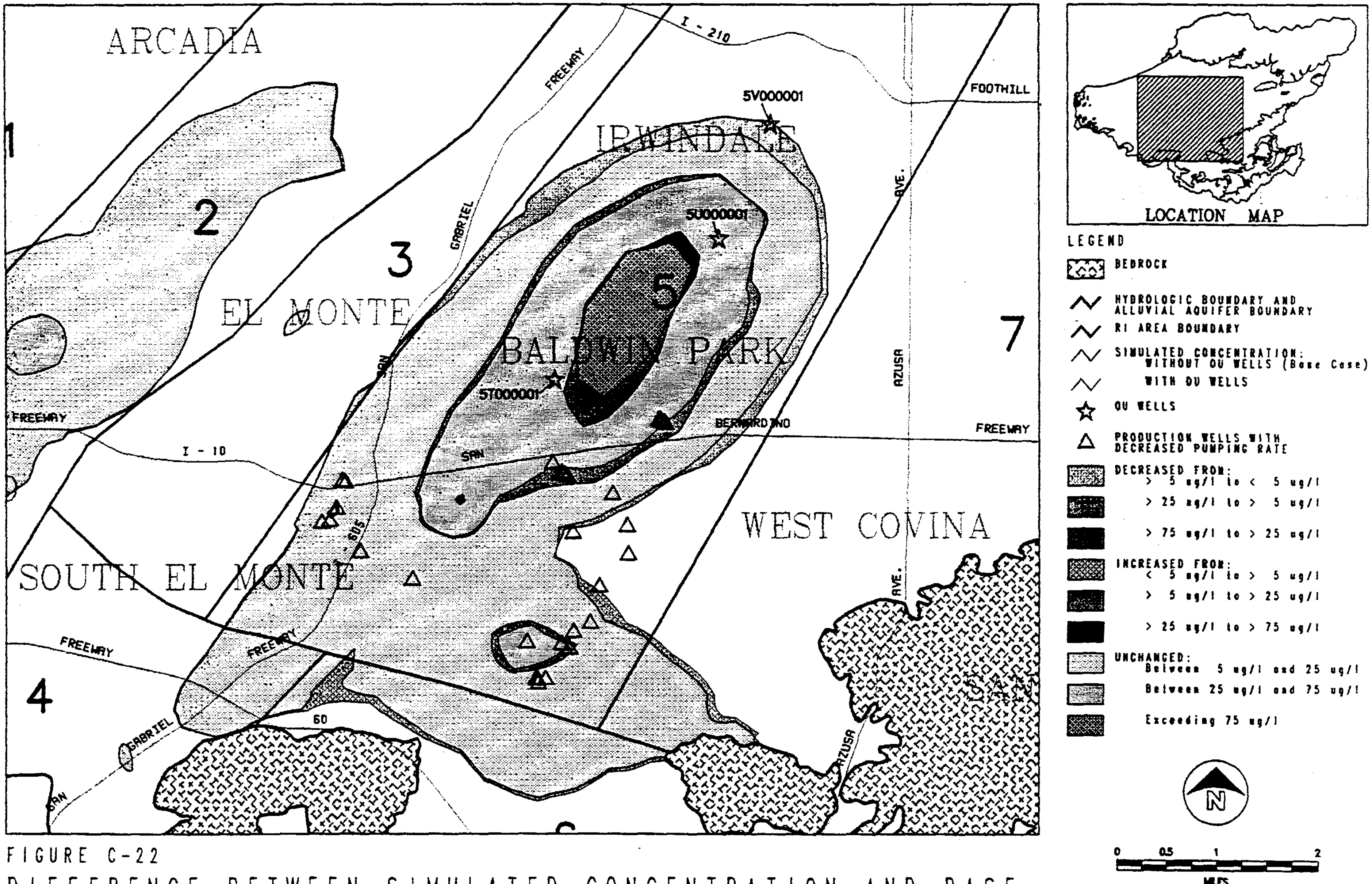

FIGURE C-22

DIFFERENCE BETWEEN SIMULATED CONCENTRATION AND BASE CASE CONCENTRATION AFTER 9.75 YEARS FOR OU5TUV

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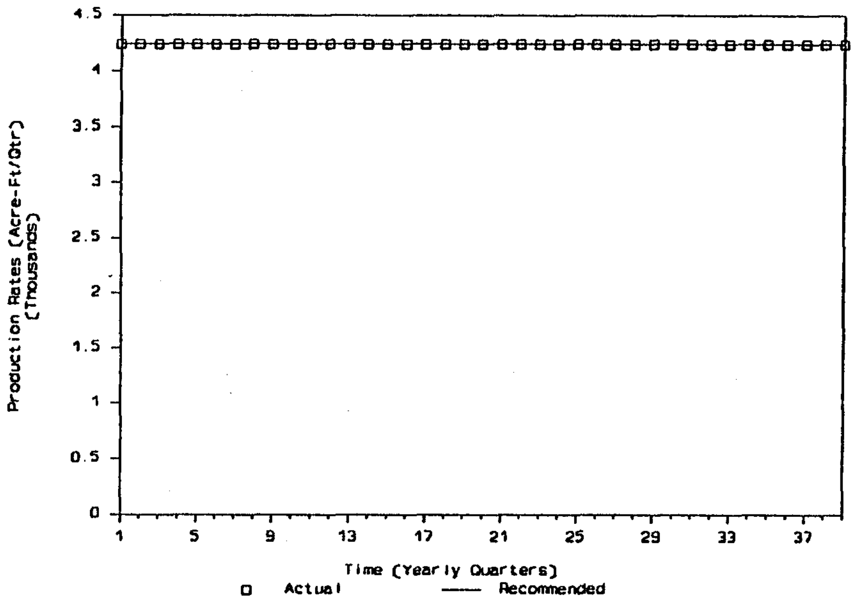

Figure C-21: OU 5TUV - Recommended vs Actual Production Rate

to most wells in the base case. The increase in areal extent of the contaminated zone in the southern part of the area is probably the result of decreased production in that region. The decreased production allows local groundwater flows to be influenced more by regional groundwater flows than by nearby production.

Recharge into Area 5 occurs from the north and from Puente Valley to the southeast (Figure C-4). Groundwater flow within Area 5 is primarily toward the southwest; but in the southern portion, it is in a westerly direction because of inflow from Puente Valley. Heads are reduced the most by this OU within Area 5 because hydraulic gradients are significantly greater there than in other areas.

Vectors of groundwater flow for the OU and base case simulations are compared in Figure C-23. Although very slight shifts from base case flow directions are evident over a relatively large portion of the basin, overall the regional effects of this OU are small. The greatest changes in flow directions occur in the immediate vicinity of the OU extraction wells, and in southeastern Area 5, near the mouth of the Puente Valley where a large number of wells have been turned off. Because two of the OU wells border nitrate contamination above MCLs, it is clear that nitrates can be expected to be extracted from these wells throughout the lifetime of this OU. Pumping at these wells will shift the regional southwesterly flow direction somewhat more to the west, which may hasten the spread of contaminants toward them. However, as shown in Figure C-23, nitrate contamination may be expected to reach the northern two OU wells whether or not they are returned to production. Furthermore, it appears likely that extraction and treatment at these wells may delay nitrate contamination from migrating past them to the west and southwest in this northern area of Area 5.

The goal of OU 5TUV of removing contamination from Area 5 appears to be effectively addressed, given the assumptions of actual extent of contamination represented in the numerical model. Contamination exceeding 25 ug/l is removed as indicated in Figure C-22. Although the extent of contamination indicated by the 5 ug/l and 25 ug/l contours appears relatively unchanged, a substantial amount of contamination is removed. The total mass of contaminants removed in the OU 5TUV simulation is estimated at 8,457 lb. The rate of contaminant removal decreases steadily as a function of time (Figure C-24). This is, again, a function of source-related assumptions, and a result of locating the OU wells within the central, most highly contaminated zone in Area 5 and indicates that these higher contaminant concentrations (and mass) are withdrawn first. The complete removal of contamination from the area would take at least 20 to 30 years if no continuing sources are present. It should be noted that much of the removal would be effected by the continuing southward migration of contaminants, which is not much affected by this OU.

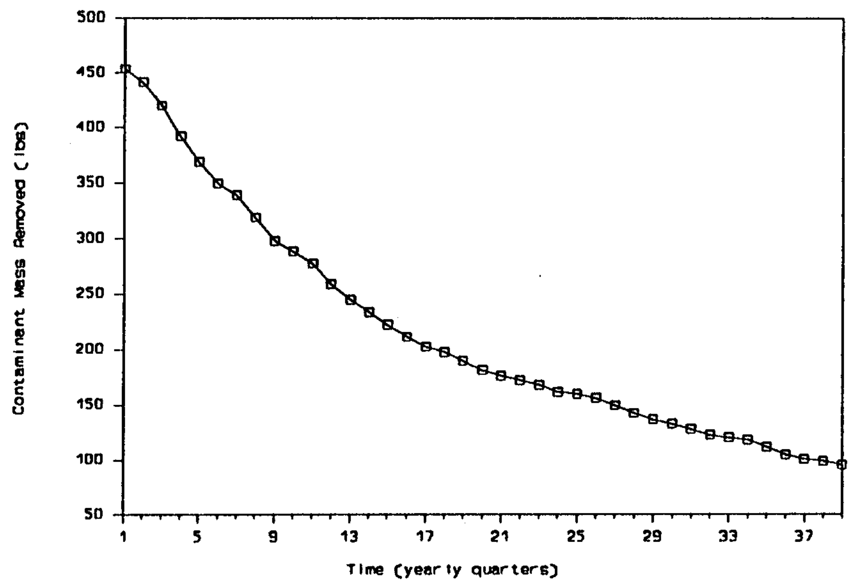

Figure C-24: OU 5TUV - Contaminant Mass Removed vs Time

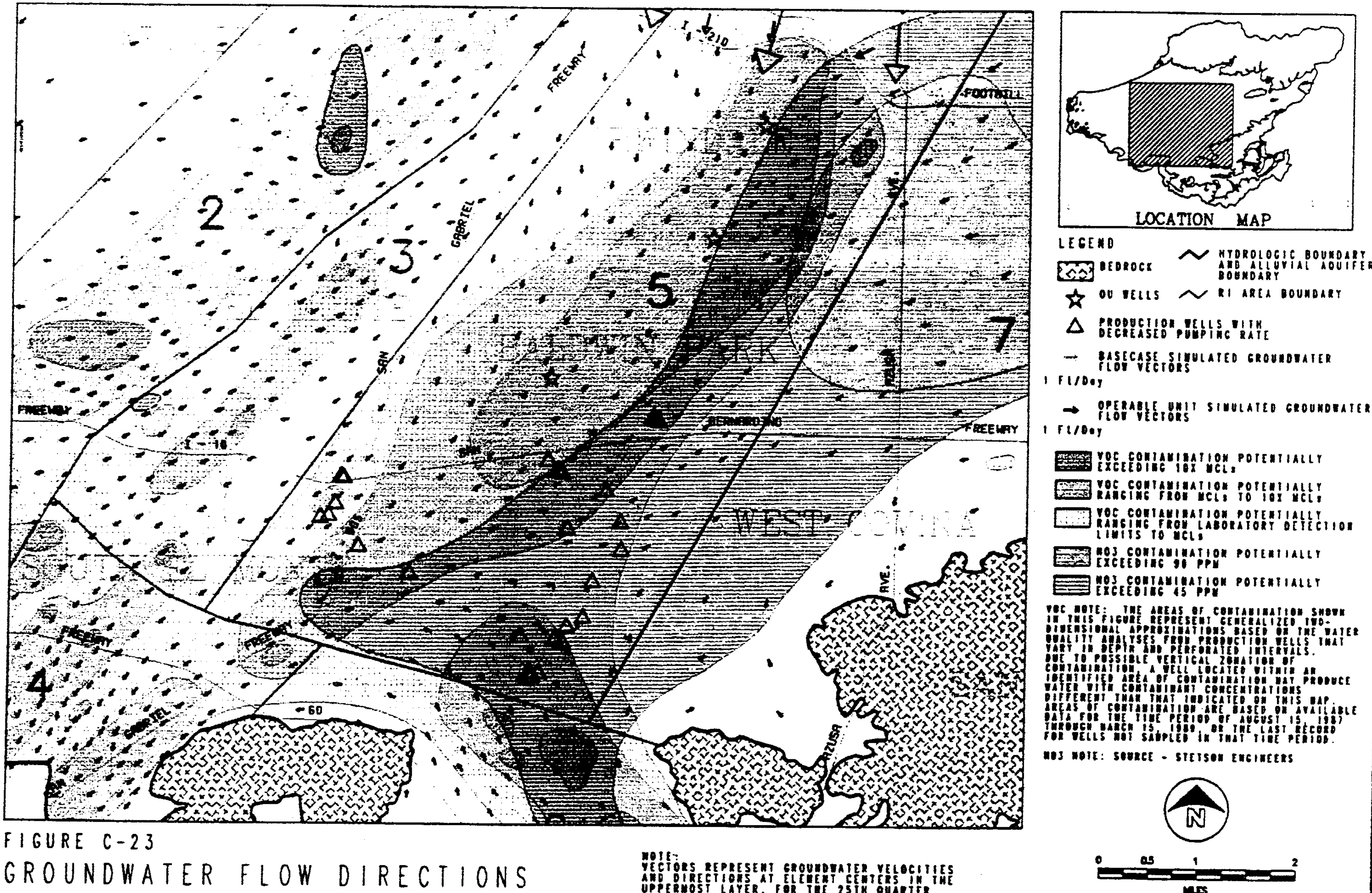

FIGURE C-23
GROUNDWATER FLOW DIRECTIONS WITH AND WITHOUT OU5TUV

NOTE:
VECTORS REPRESENT GROUNDWATER VELOCITIES AND DIRECTIONS AT ELEMENT CENTERS IN THE UPPERMOST LAYER, FOR THE 25TH QUARTER SIMULATED (FALL, 1983). VELOCITIES SHOWN ARE DARCY VELOCITIES.
(ACTUAL VELOCITY = DARCY VELOCITY/POROSITY)

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C.3.6 OPERABLE UNIT 5CDGFIJ

The objective of operable unit 5CDGFIJ, as with 5TUV, is to remove contamination from Area 5 (Figure A-5b and A-5c), in this case by using 13 existing wells with a combined production rate of 13,139 ac-ft/qtr. The production rates of the wells located within areas exceeding MCLs is recommended to vary from 400 to 4,200 gpm in Appendix A, based on varying individual capacities. The main contaminated region extends approximately 2 miles from the northern boundary to just within the Area 4 as described by the MCL contour. In the southeastern region of Area 5, a second zone of contamination with concentrations exceeding MCLs extends into Area 6.

Wells turned off downgradient and upgradient of the OU wells do not meet the 13,139 ac-ft/qtr increase in OU production. Thus, OU production is decreased to the extent necessary to meet the available surrounding production (an average of approximately 11,200 ac-ft/qtr over 39 quarters [Table C-3]). Figure C-25 shows the recommended OU production compared to the actual simulated OU production for the 39 quarters. Wells at which pumping is turned off or reduced in the OU 5CDGFIJ simulation are listed in Table C-2.

Effects on the location and extent of the major zone of contaminant migration in Area 5 does not appear significantly different as a result of OU 5CDGFIJ pumping as for OU 5TUV pumping. After 10 years, contamination migrates approximately 1 to 2 miles to the south. As shown in Figure C-26, the 5 ug/l contour in the OU simulation appears to migrate in an easterly direction in Areas 6 and 7, and southern Area 5, increasing the extent of contamination by approximately 5 percent as compared to the base case. Contamination 3^Dso appears to migrate to the west, toward Whittier Narrows. In the central part of Area 5, the results of the OU simulation indicate that the zone of VOC contamination above 5 ug/l is reduced by approximately 10 to 15 percent overall. The zone contaminated above 25 ug/l is reduced by approximately 20 percent at the north end of the main zone of contamination in Area 5. In less than 10 years, these percentages correspond to a total decrease in the areal extent of zones contaminated above 5, 25, and 75 ug/l in the central portion of Area 5 of about 6.5 square miles. A small increase of about 0.6 square miles near the Puente Valley also occurs.

As described previously, groundwater flow within Area 5 is primarily toward the southwest. In the southern portion of Area 5, there is a strong component of westerly flow. The results of the OU simulation indicate that hydraulic heads are lowered in Areas 6 and 7, downgradient and to the northeast of Area 5, respectively. Again, heads are reduced the most within Area 5 itself; although, towards the north because the hydraulic gradients are significantly greater, no head changes are indicated.

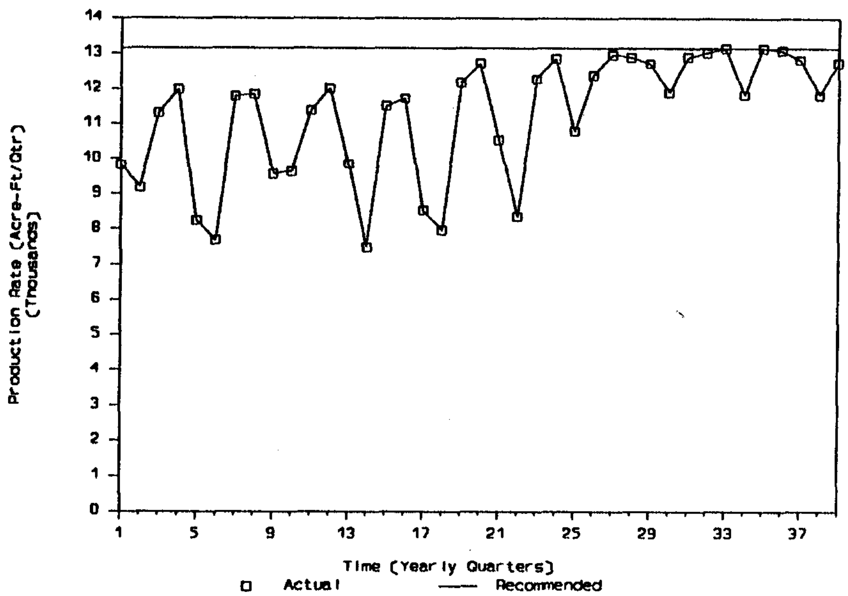


Figure C-25: OU 5CDGFIJ - Recommended vs Actual Production Rate

In general, groundwater flow directions and magnitudes throughout the San Gabriel Basin are similar in the base case and OU 5CDGFIJ simulations. Flow vectors for the two simulations are compared in Figure C-27. The greatest changes in flow directions occur in the vicinity of some of the OU extraction wells, and in areas surrounding clusters of wells at which pumping is reduced or eliminated, particularly in the low-gradient area near the mouth of the Puente Valley. Although very slight shifts in flow directions occur on a regional scale, the overall effect on regional flow is negligible. The OU 5CDGFIJ wells are close enough to the westernmost boundary of nitrate contamination above MCLs to assume that substantial nitrate contamination will be extracted along with VOCs. In fact, the predominant southwestern flow may be expected to carry nitrates into the vicinity of some of these wells whether or not production is resumed. As with OU 5TUV, OU 5CDGFIJ wells will probably form a fairly effective barrier to continued migration of nitrate contamination in the northern parts of the basin. Some additional spread of nitrate contamination, however, may result from pumping of the southernmost OU wells, and corresponding reductions in pumping in the southeast corner of Area 5.

The total mass of contaminants removed after almost 10 years is estimated at 52,813 lb. Again, the rate of contaminant removal decreases as a function of

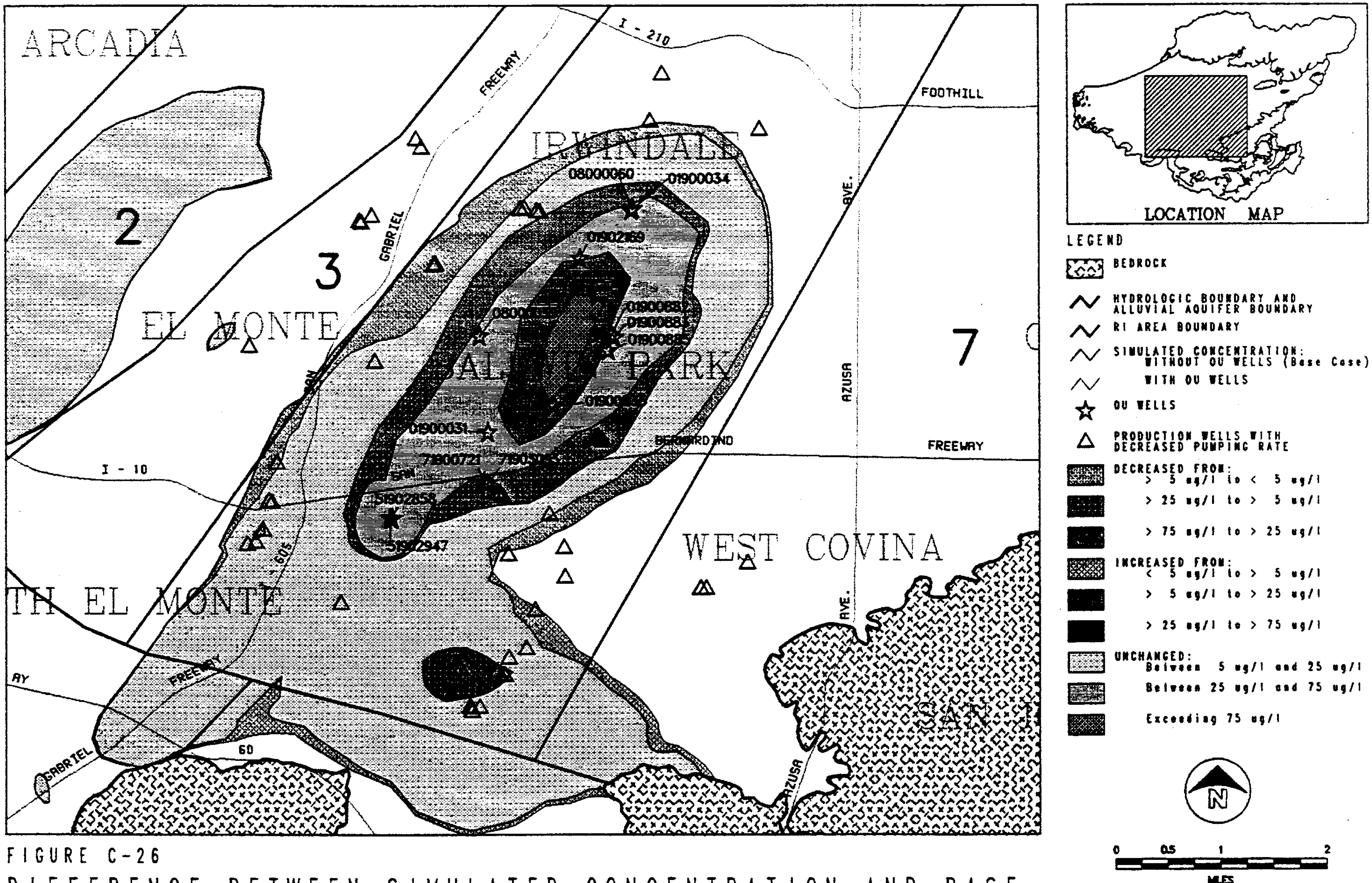
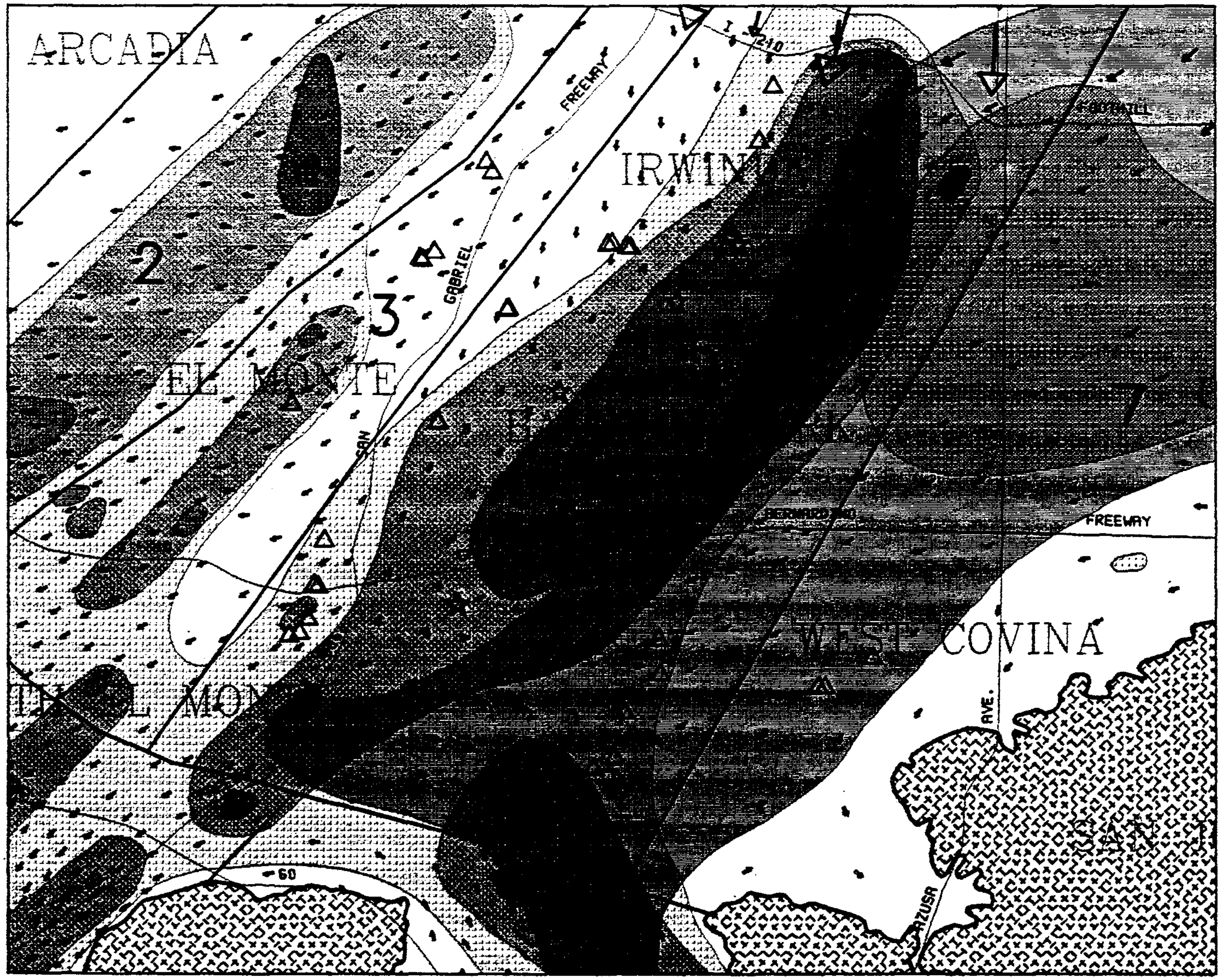
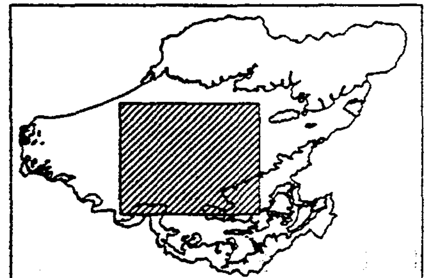


FIGURE C-26

DIFFERENCE BETWEEN SIMULATED CONCENTRATION AND BASE CASE CONCENTRATION AFTER 9.75 YEARS FOR OU5CDGFIJ





LOCATION MAP

LEGEND

BEDROCK

OU WELLS

PRODUCTION WELLS WITH DECREASED PUMPING RATE

BASECASE SIMULATED GROUNDWATER FLOW VECTORS

1 Ft/Day

OPERABLE UNIT SIMULATED GROUNDWATER FLOW VECTORS

1 Ft/Day

VOC CONTAMINATION POTENTIALLY EXCEEDING 10X MCLs

VOC CONTAMINATION POTENTIALLY RANGING FROM MCLs TO 10X MCLs

VOC CONTAMINATION POTENTIALLY RANGING FROM LABORATORY DETECTION LIMITS TO MCLs

NO3 CONTAMINATION POTENTIALLY EXCEEDING 90 PPM

NO3 CONTAMINATION POTENTIALLY EXCEEDING 45 PPM

HYDROLOGIC BOUNDARY AND ALLUVIAL AQUIFER BOUNDARY

RI AREA BOUNDARY

VOC NOTE: THE AREAS OF CONTAMINATION SHOWN IN THIS FIGURE REPRESENT GENERALIZED TWO-DIMENSIONAL APPROXIMATIONS BASED ON THE WATER QUALITY ANALYSES FROM PRODUCTION WELLS THAT VARY IN DEPTH AND PERFORATED INTERVALS. DUE TO POSSIBLE VERTICAL ZONATION OF CONTAMINATION, A WELL LOCATED WITHIN AN IDENTIFIED AREA OF CONTAMINATION MAY PRODUCE WATER WITH CONTAMINANT CONCENTRATIONS DIFFERENT THAN THAT INDICATED ON THIS MAP. AREAS OF CONTAMINATION ARE BASED ON AVAILABLE DATA FOR THE TIME PERIOD OF AUGUST 15, 1987 THROUGH MARCH 15, 1988, OR THE LAST RECORD FOR WELLS NOT SAMPLED IN THAT TIME PERIOD.

NO3 NOTE: SOURCE - STETSON ENGINEERS

N

0 0.5 1 2

MILES

FIGURE C-27

GROUNDWATER FLOW DIRECTIONS
WITH AND WITHOUT OU5CDGFIJ

NOTE:
VECTORS REPRESENT GROUNDWATER VELOCITIES AND DIRECTIONS AT ELEMENT CENTERS IN THE UPPERMOST LAYER, FOR THE 25TH QUARTER SIMULATED (FALL, 1983). VELOCITIES SHOWN ARE DARCY VELOCITIES.
(ACTUAL VELOCITY = DARCY VELOCITY/POROSITY)

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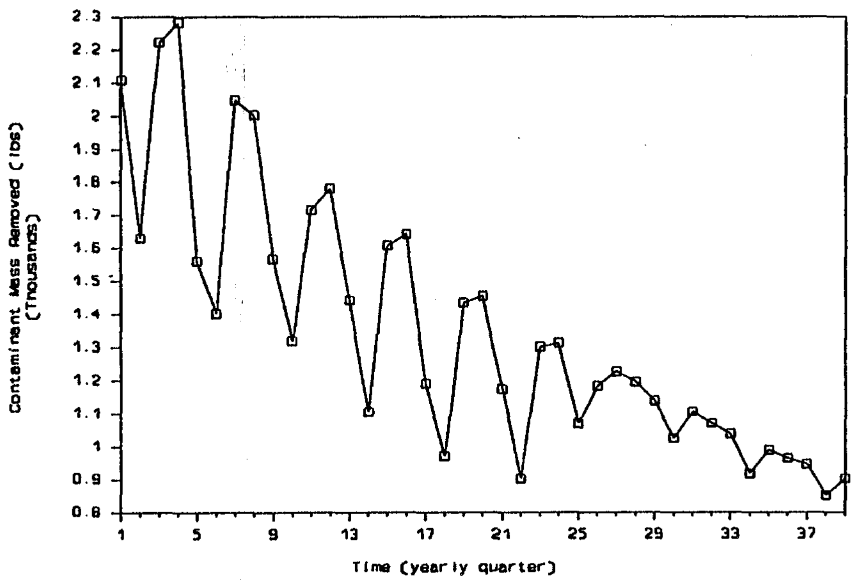

Figure C-28: OU 5CDGFIJ - Contaminant Mass Removed vs Time

time (Figure C-28). The oscillation in the rate of removal reflects the variation in production as a function of time.

OU 5CDGFIJ appears capable of a high degree of contaminant removal; contamination exceeding 25 ug/l may apparently be removed entirely from the southeastern portion of Area 5 after only 10 years, if there are no continuing sources of contamination, as indicated in Figure C-26. Compared to OU 5TUV, OU 5CDGFIJ removes contamination approximately 2.5 times more effectively. Again, remedial investigations performed prior to implementation of this OU will allow considerable refinement in well design. However, the large mass of contamination removed in the numerical simulation indicates a huge potential for substantially reducing contamination in Area 5 with an action of this type. Furthermore, although contaminants removed by OU 5CDGFIJ wells will be limited to the intervals penetrated by the existing wells, supplemental extraction by new wells (i.e., OU 5TUV) would prove even more effective in removing contaminants from throughout the aquifer, particularly from great depths not influenced by existing wells.

C.3.7 OPERABLE UNIT 5W

The objective of OU 5W is the protection of a large regional pumping center, located just above Area 6 in the southeastern corner of Area 5, from contamination upgradient in Area 6. The OU uses four new wells, located in Area 5 just upgradient of the pumping center, with a combined production of 10,000 gpm or 4,040 ac-ft/qtr; each well is assigned a recommended production of 2,500 gpm in Appendix A. These wells are within a zone with VOC contamination exceeding MCLs in the southeastern corner of Area 5, an extension of the main above-MCL zone in Area 6 (Figure A-5a).

Wells turned off downgradient of the OU wells do not meet the 4,040 ac-ft/qtr increase in OU production; therefore, the recommended OU production is decreased accordingly. Average OU production over 39 quarters is approximately 3,850 ac-ft/qtr (Table C-3), a small deviation from the recommended OU production. Figure C-29 shows the recommended OU production compared to the simulated OU production for the 39 quarters. Wells at which pumping is eliminated or reduced in the OU 5W simulation are listed in Table C-2.

Results of the OU 5W and base case simulations are compared in Figure C-30. Migration of the large zone of contamination in Area 6 appears to be prevented by the OU wells, thereby successfully protecting the pumping center as indicated in Figure C-30. Contamination of 25 ug/l or greater is centered around the OU wells on the border of Areas 5 and 6. The primary zone of contamination in Area 5 migrates approximately 1 to 2 miles to the south. At its southern extent, this zone appears to migrate to the southwest, toward Whittier Narrows in Area 4. These levels of contamination are indicated by the 5 ug/l contour.

Relative to the base case, the results of the OU simulation indicate that the zone contaminated above 5 ug/l is reduced by approximately 15 percent. This reduction occurs primarily in the southern portion of Area 5, with some reduction taking place in the northwestern portion of Area 6. The greater than 25 ug/l zone is reduced by approximately 10 percent in the same locations. The overall areal extent of potential contamination greater than 25 ug/l that is prevented by this OU is 3.14 square miles. In the northern parts of Area 5, the main zone of contamination does not appear to undergo significant change from the base case.

The results of the OU simulation indicate that hydraulic heads are lowered in Areas 1, 2, 3, and 5. At the south end of Area 5, a cone of depression develops around the 5W wells, and extends into the northwestern portion of Area 6. Groundwater flow lines are oriented more toward the OU wells in the southern end of Area 5 than in the base case.

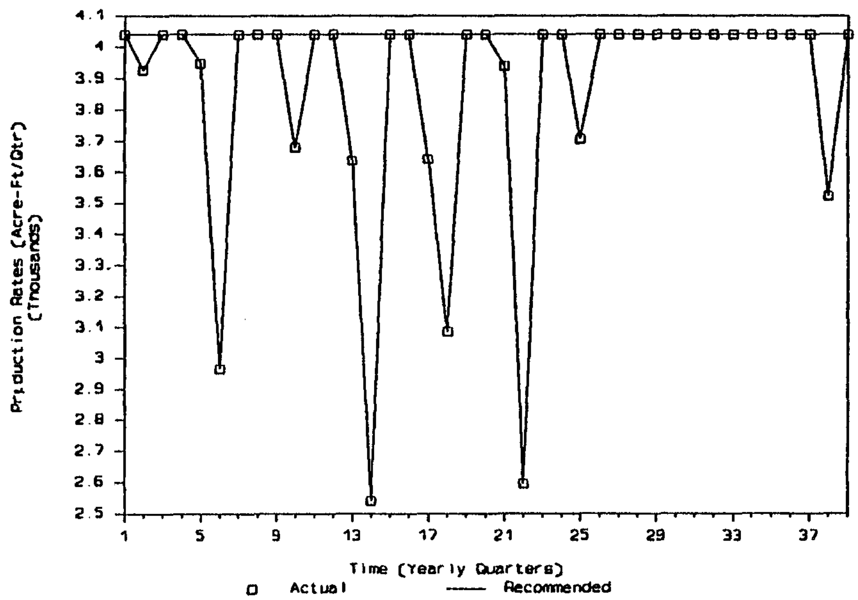

Figure C-29: OU 5W - Recommended vs Actual Production Rate

Vectors representing groundwater-flow directions and magnitudes simulated for both OU and basecase pumping patterns are shown in Figure C-31. Flow throughout the southeastern Area 5, northern Area 6, and the southwestern corner of Area 7, is substantially affected. Most of the changes in direction occur toward the OU wells. The shifts in the extent of contamination in central Area 5 shown in Figure C-30 can be seen in Figure C-31 to be the result of shifts in flow directions in that area. Nitrates occur above MCLs throughout the area and are expected to be a significant component of the contaminants extracted at the OU wells. Overall, the effects of the OU wells on the current extent of nitrate contamination may well be beneficial: much of the south-westerly flow that has been responsible for spreading nitrate contamination in the area will be diverted in southerly and southeasterly directions toward the OU wells.

The VOC contamination exceeding 25 ug/l appears to be significantly reduced in Areas 5 and 6 after 10 years. The total mass of contaminants removed in the OU 5W simulation is estimated at 3,799 lb, in the absence of continuing sources of contamination. The rate of contaminant removal increases sharply for a few quarters and then decreases as a function of time (Figure C-32). The initial increase in the rate of removal is a result of the relatively rapid withdrawal of higher levels of contamination, upgradient in the Puente Valley. Oscillations in the rate of removal reflect variations in production as a function of time.

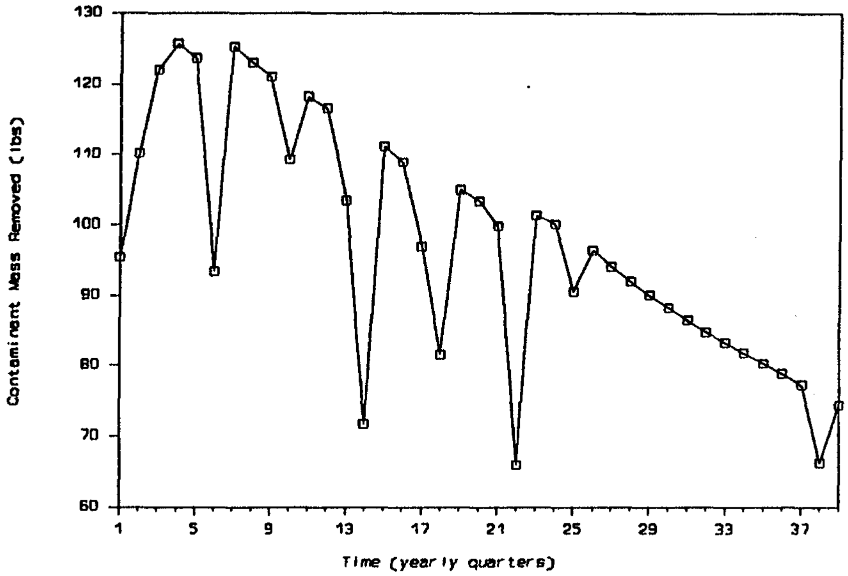

Figure C-32: OU 5W - Contaminant Mass Removed vs Time

In the simulation, OU 5W accomplishes its objective of preventing further contamination of groundwater at the pumping center in the southeastern region of Area 5. In the base case, groundwater flows from Area 6 through the pumping center in the southeastern region of Area 5 and then continues southwest towards Whittier Narrows, allowing contamination to pass through the pumping center as it is transported through Area 4. In the OU simulation,contamination from the Puente Valley, however, is captured earlier and more effectively than in the base case because of the greater localized production upgradient of the pumping center in Area 5, relative to the base case production in the same area.

C.3.8 OPERABLE UNIT 6AB

The original objective of OU 6AB, as stated in Appendix A, is to provide additional treated groundwater to Puente Valley. This OU utilizes five existing wells currently shut down because of poor water quality. The OU wells will supply a total production of 1,312 ac-ft/qtr if pumped at capacity with production rates ranging from less than 100 to 1,500 gpm. These wells are located within the zone contaminated above MCLs in the central part of Area 6. Contamination is present throughout much of Area 6 with concentrations exceeding MCLs as indicated in Figure A-6.

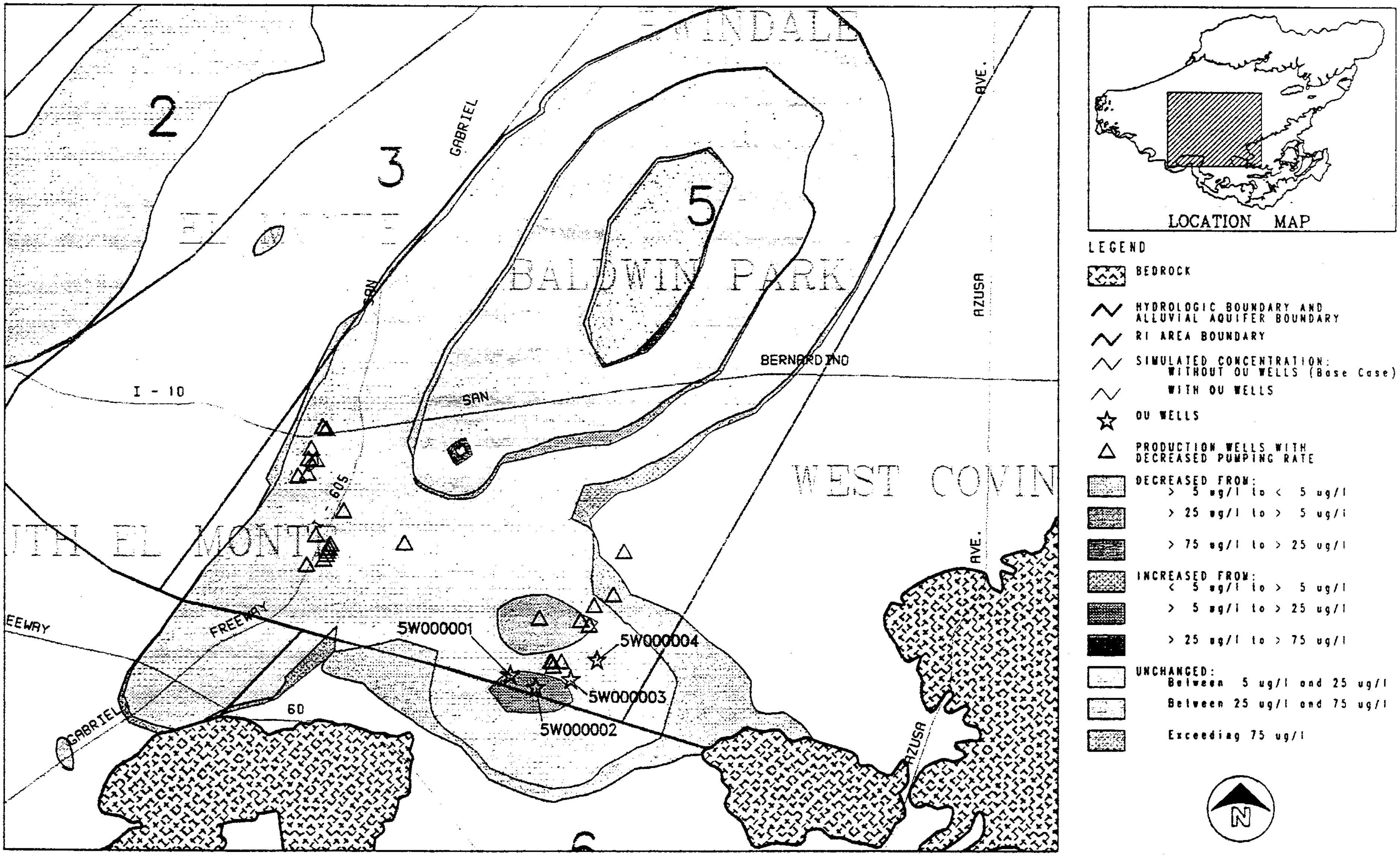

FIGURE C-30

DIFFERENCE BETWEEN SIMULATED CONCENTRATION AND BASE CASE CONCENTRATION AFTER 9.75 YEARS FOR OU5W

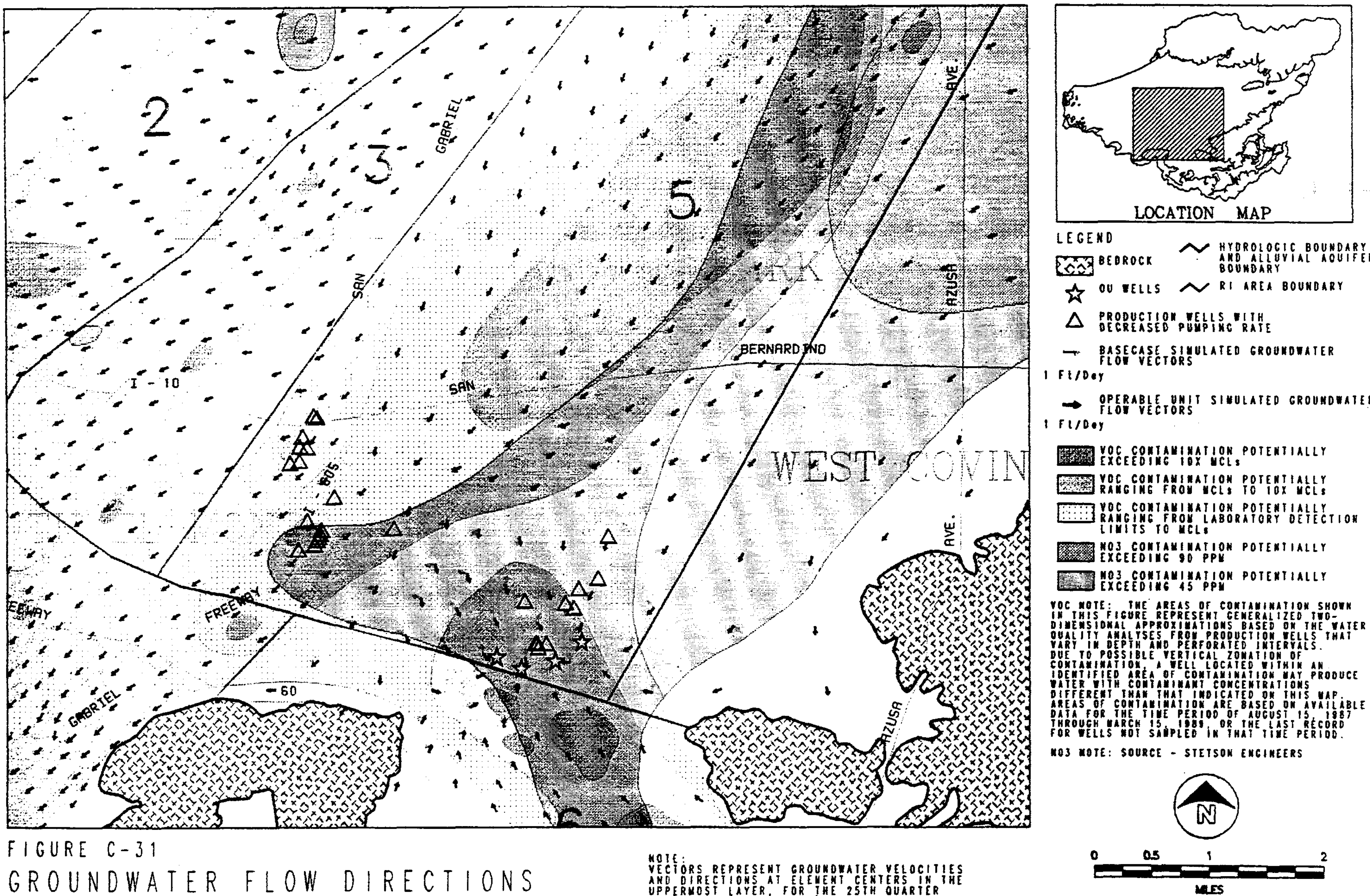

FIGURE C-31
GROUNDWATER FLOW DIRECTIONS
WITH AND WITHOUT OU5W

NOTE:
VECTORS REPRESENT GROUNDWATER VELOCITIES AND DIRECTIONS AT ELEMENT CENTERS IN THE UPPERMOST LAYER, FOR THE 25TH QUARTER SIMULATED (FALL, 1983). VELOCITIES SHOWN ARE DARCY VELOCITIES.
(ACTUAL VELOCITY = DARCY VELOCITY/POROSITY)

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Wells turned off downgradient of the OU wells do not meet the 1,312 ac-ft/qtr increase in OU production. Therefore, OU production is decreased accordingly in the OU simulation. Average OU production over 39 quarters is approximately 1,000 ac-ft/qtr (Table C-3). Figure C-33 shows the OU production recommended in Appendix A compared to the simulated OU production for the 39 quarters. Wells at which pumping is turned off or reduced in the 6AB simulation are listed in Table C-2.

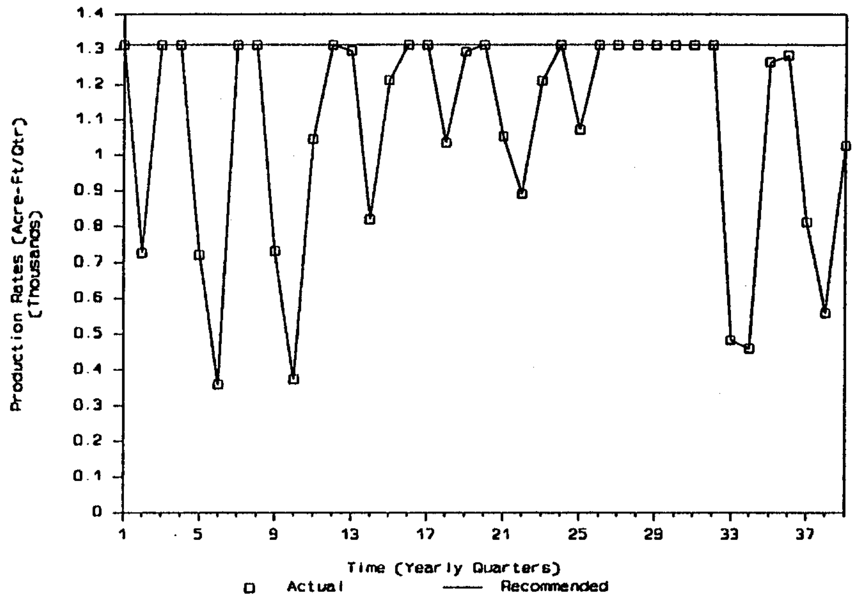

Figure C-33: OU 6AB - Recommended vs Actual Production Rate

The OU 6AB simulation results are compared to the base case in Figure C-34. The upgradient extent of contamination in Figure C-34 (represented by the 5 ug/l contour) appears to have migrated toward the Area 5 boundary. Migration of the 5 ug/l contour at the southern margin of contamination in Area 6 is slowed because of the effect of OU production upgradient of this point in the Puente Valley. The zone contaminated above 5 ug/l increases in areal extent by approximately 5 percent (about 0.6 square miles) in Area 6, and decreases by approximately 5 percent (about 0.6 square miles) in Area 5. Contamination of 25 ug/l or greater is completely removed from Area 6 in the absence of continuing sources as indicated by the 25 ug/l contour in Figure C-34. Contamination exceeding 25 ug/l in the southeastern region of Area 5 increases by approximately 25 percent in areal extent in response to the decrease in production in this area. The direction of this increase in a real extent is toward Area 6. The OU production in Area 6 affects the extent of contamination in Area 7, as indicated by the 5 ug/l contour which appears to be drawn more toward Area 6. Other zones of contamination within the basin do not appear affected by the OU simulation.

Groundwater in Area 6 flows toward the west throughout most of the Puente Valley (Figure C-4). Toward the western end of Area 6, groundwater discharges into the main part of the basin to the north to northwest. The OU simulation results indicate that only in Area 6 are water levels lowered in response to the OU well. The greatest change in heads within Area 6 occurs upgradient of the OU wells.

Most of the change in groundwater flow directions, however, results from the elimination of the depression in the potentiometric surface surrounding wells turned off in southeastern Area 5. As shown in Figure C-35, in which vectors from the OU and base case simulations are compared, dramatic changes in flow directions away from the turned off wells occur. Due to the considerable effect of reducing pumping at these wells, a feasibility study of this OU should carefully consider how best to balance the additional water produced through OU extraction.

Within the Puente Valley itself, flow directions are shifted in a more northerly direction downgradient of the OU wells. The resultant deterrence of westward migration out of the Puente Valley may be one of the more important effects of this action. As was seen in Figure C-34, the spread of VOCs occurring west of the mouth of the valley is reduced, while the extent of contamination at the valley mouth itself is increased. This degree of migration control is remarkable in an OU as small as this one that relies on existing wells. Used in conjunction with other actions that address contamination at the valley mouth itself, it may prove effective as a means of managing migration out of the valley toward Whittier Narrows.

The migration of nitrate contamination above MCLs, which occurs throughout the area, may not be significantly altered by OU 6AB. However, the extent of nitrate contamination in the area is highly interpretative in the western corner of Area 6 where there are almost no data available. If nitrates are present in that area, their migration toward Whittier Narrows will be slowed in the same way VOC contamination is affected.

The OU 6AB achieves its objective of providing additional treated groundwater to Area 6 without significantly increasing the contaminant levels or areal zones simulated in the base case (Figure C-34). However, a degree of migration control west of the mouth of the Puente Valley appears to be an important by-product of pumping these wells. The OU wells remove a total of 567 lb of contaminants from the OU wells, which would have eventually migrated into Area 5 if not extracted at the OU wells. The rate of contaminant removal, which again decreases as a function of time in the absence of continuing sources (Figure C-36), oscillates in response to the variation in production.

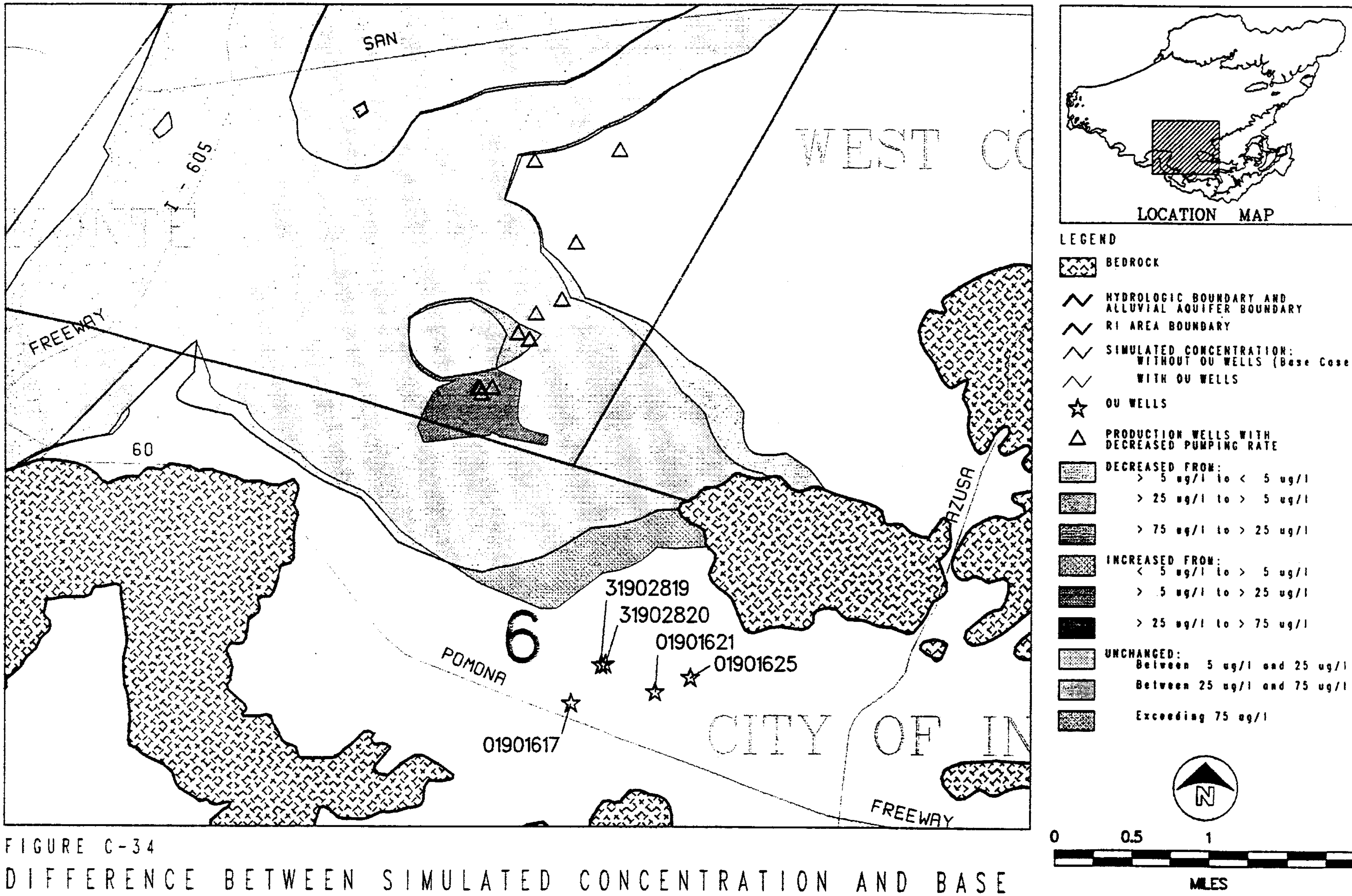

FIGURE C-34

DIFFERENCE BETWEEN SIMULATED CONCENTRATION AND BASE CASE CONCENTRATION AFTER 9.75 YEARS FOR OU6AB

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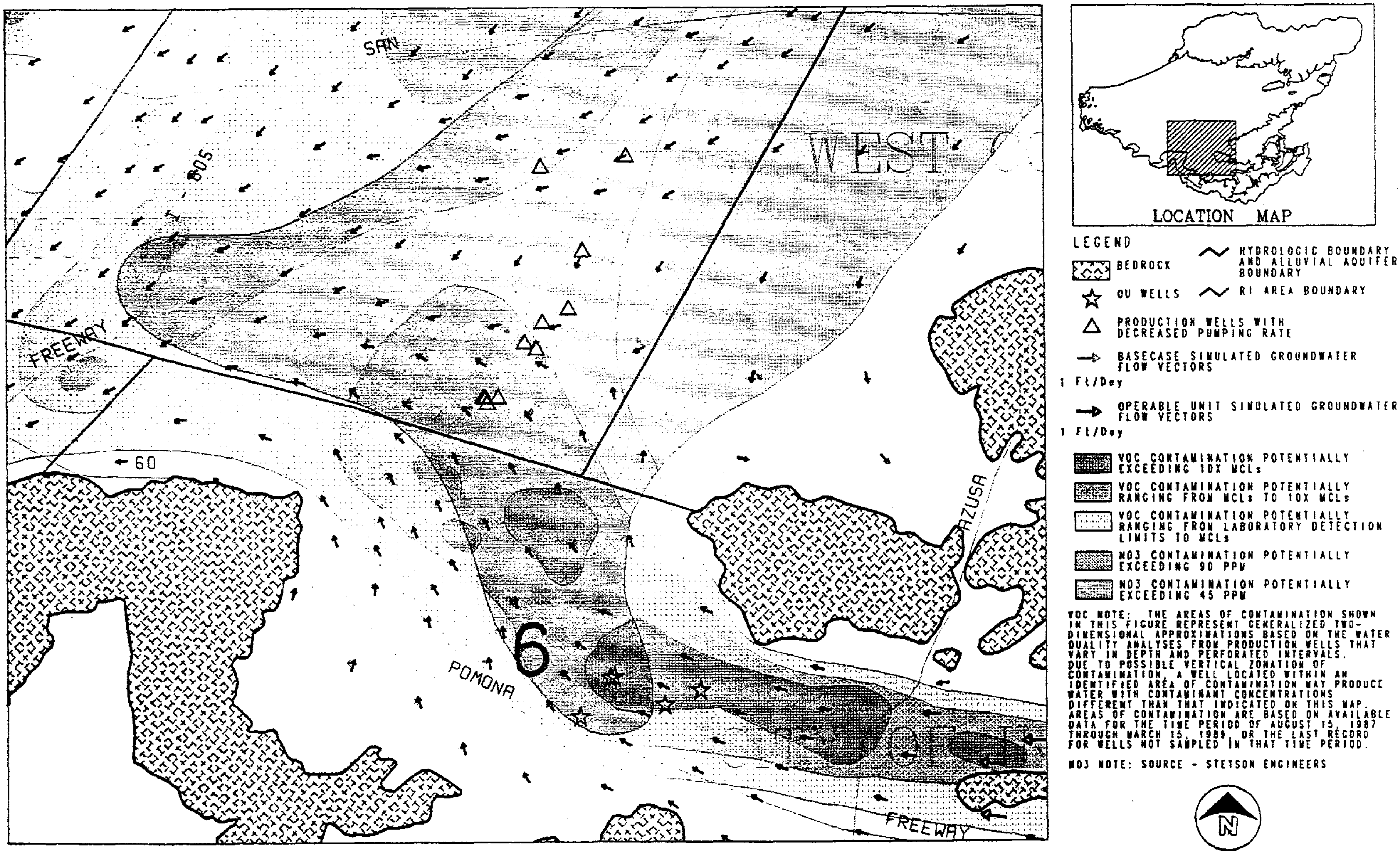

FIGURE C-35

GROUNDWATER FLOW DIRECTIONS WITH AND WITHOUT OU6AB

NOTE:
VECTORS REPRESENT GROUNDWATER VELOCITIES AND DIRECTIONS AT ELEMENT CENTERS IN THE UPPERMOST LAYER, FOR THE 25TH QUARTER SIMULATED (FALL, 1983). VELOCITIES SHOWN ARE DARCY VELOCITIES.
(ACTUAL VELOCITY = DARCY VELOCITY/POROSITY)

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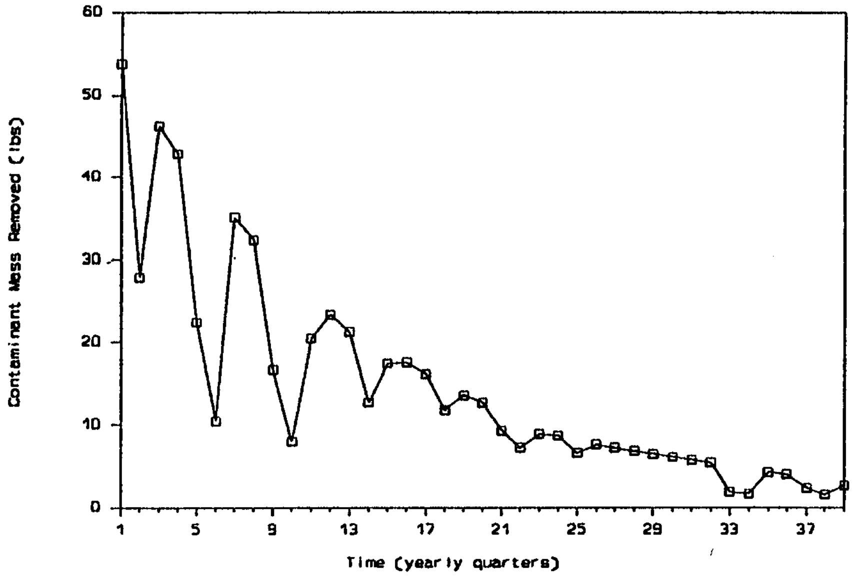

Figure C-36: OU 6AB - Contaminant Mass Removed vs Time

C.4.0 REFERENCES

Gupta, S. K., C. R. Cole, C. T. Kincaid, and A. M. Monti. Coupled Fluid, Energy, and Solute Transport Model. Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbia, Ohio. October 1987.

U.S. Environmental Protection Agency. Draft Report of Remedial Investgations, San Gabriel Basin, Los Angeles County, California. Prepared for EPA Region IX by CH2M HILL. November 1, 1989.

Appendix D
WATER SUPPLY AND DISTRIBUTION ANALYSES - REPRESENTATIVE SUBSET OF POTENTIAL OPERABLE UNITS

APPENDIX D

CONTENTS

APPENDIX D

TABLES

APPENDIX D

FIGURES

APPENDIX D
WATER SUPPLY AND DISTRIBUTION ANALYSES - REPRESENTATIVE SUBSET OF POTENTIAL OPERABLE UNITS

D.1.0 INTRODUCTION

Management of San Gabriel Basin water is a complex undertaking involving two watermasters, three municipal water districts, 45 water purveyors, and 105 individual water-right holders. About 230,000 acre-feet of groundwater are extracted annually for domestic, municipal, and industrial use. Based on available data, groundwater contamination above federal and state maximum contaminant levels (MCLs) may occur in almost 20 percent of the basin area.

For basinwide planning, eight representative operable units (OUs) have been evaluated. The selection of 8 OUs from the 38 described in Appendix A is documented in Section 5.0. These remedial actions typically involve extraction of contaminated water at OU wells, eliminating or reducing production from downgradient and upgradient wells, treating the extracted groundwater to remove contaminants to concentrations within drinking water standards, and redistributing the treated water to replace the wells taken out of service or at which production is decreased (collectively referred to as "shut-down" wells in this appendix). Appendix C describes the production rates of the OU wells, production adjustments at the shut-down wells, and an evaluation of the potential effects of OU actions on groundwater flow and contaminant transport.

This appendix includes, for each OU, information on the owners of OU wells and shut-down wells, the potential number and location of treatment facilities, and estimates of the size and length of pipeline required to redistribute the treated water. A general discussion of related topics precedes the OU evaluations.

Redistribution of treated water to areas served by shut-down wells is an important aspect of estimating costs for implementation of the OUs. Detailed information on existing water distribution pipeline systems, the physical conditions of the pipe lines, network operation details, pipeline ownership and other related factors for the 45 water purveyors in the San Gabriel Basin has not been compiled. Therefore, at this stage, evaluations of the use of existing pipelines to distribute treated water is difficult. To develop cost estimates for implementation of the OUs, two alternate pipeline alignments have been developed with which to redistribute water from the OU treatment plants. Assumptions regarding the use of existing pipelines, and the point at which treated water is delivered, are the primary differences between the two water distribution alternatives evaluated.

The first alternative assumes that all existing pipelines that are 12 inches or greater in diameter will be available to redistribute water to areas currently serviced by wells at which pumping will be reduced or eliminated as part of OU actions. Though available data describe an extensive network of existing pipelines, the location of all pipelines is not known. In the figures accompanying this appendix, some purveyor service areas lack any pipelines 12 inches or greater in diameter. Where no pipeline information is available, it is assumed that a network of pipes does exist and only a connection to this network at the boundary of the purveyors service is required to connect into the existing distribution system. In most cases, pipeline alignments for this scenario are designed to deliver treated water from the OU wells to treatment centers, and from there to large existing pipelines. It is recognized, however, that during the actual design and implementation of OUs, the use of existing pipelines will be limited because of the other demands on the existing conveyance systems. Actual pipeline designs will require extensive data compilation and analysis to properly evaluate the feasibility of using the existing network to redistribute treated water.

Because detailed, OU-specific studies of this type are beyond the scope of this report, a second scenario has been developed in which new pipelines have been included to deliver treated water from the OU treatment plants to the shut-down wells. In this scenario, treated water is delivered to the wells at which production has been substantially reduced or eliminated at a rate that is comparable to production rates at these wells over the last 10 years. The second scenario does not consider the use of existing pipelines at all.

Costs associated with constructing new pipelines are likely to be higher than those incurred by using the existing pipeline network to the extent possible. In many contaminated areas, contaminated wells have been replaced by new wells outside the currently contaminated areas. Thus, at many of the representative OUs, the area served by the shut-down wells is closer to the OU wells. Under such conditions, the first scenario may be most representative of the final design developed during OU-specific feasibility studies (FS). In other cases, especially where most, if not all, of the OU extraction wells are new, considerably more pipeline will be required. The two alternate scenarios developed are intended to encompass among them many of these potential complexities, and it can be generally said that actual pipeline development costs may fall somewhere between the costs estimated for each of the two alternatives.

It should be emphasized, however, that prior to implementation of any OU, an FS will be conducted. The FS will evaluate in detail several alternatives involving various combinations of using existing or new wells as extraction wells along with limiting or eliminating production from other existing production wells. The cost of water distribution facilities is potentially a large component of the total OU cost. Therefore, careful consideration will be given to the selection of wells (both those at which production is decreased or increased) for inclusion in the final OU design.

As an example of the potential for refining the list of wells to be shut down to compensate for OU production, average production rates over a period of 10 years are listed in Table D-1 for the shut-down wells identified in Appendix C for OU 1E. Of the 17 wells listed, 7 pump less than 100 acre-feet per quarter (ac-ft/qtr) on an average. These 7 wells represent over 40 percent of the entire list of wells, yet have a combined total production representing about 10 percent of the total. In this case, the FS would look closely at the potential for excluding these wells, because the potential investment in distribution facilities to replace production at these wells may not be justified; the proportion of total distribution costs would not reflect the proportion of total decreased production. Furthermore, not including the small amount of production represented by these wells is unlikely to have much effect on regional hydraulic gradients, and would add little to the overall efficacy of the OU.

Table D-1
AVERAGE PRODUCTION OF SHUT-DOWN WELLS FOR OU 1E

Well ID	Average Production (ac-ft/qtr)
01900010	695.0
01900011	120.6
01900012	42.1
01900013	25.0
01900014	312.5
01900015	118.8
01900017	130.9
01900018	79.8
01900547	.6
01900934	433.0
01900935	463.2
01901671	347.3
01901679	121.9
01902785	89.8
01902789	92.7
01902979	41.4
01903059	293.1

The FS may also evaluate a variety of alternative methods of redistributing the treated water and delivery to local water purveyors. Depending on conditions at the time of implementation, it may be decided that disposal of excess water to spreading basins or river channels is preferable to redistributing the water produced at OU wells. However, as described in Appendix C, the efficacy of the OUs is typically enhanced by balancing groundwater pumping by limiting or eliminating production from existing production wells. Another alternative for redistributing treated water involves conjunctive use. A conjunctive use scenario might include exporting the treated water through the Metropolitan Water District's (MWD's) large feeder pipelines. MWD would increase recharge of the basin with imported water supplies to maintain the amount of water stored in the aquifer. By exporting the treated water, the cost of redistributing it within the basin would be avoided. Selection of the appropriate strategy will be determined on a site-specific basis for each OU.

The following sections summarize various related topics including: (1) OU impacts on the existing water supply and distribution system, (2) target treatment levels, (3) treatment technologies for volatile organic compounds (VOC) and nitrate removal, (4) treatment facility siting criteria, and (5) pipeline design assumptions.

D.1.1 POTENTIAL IMPACTS ON EXISTING WATER SUPPLY SYSTEM

Each OU modifies current groundwater extraction patterns and, in most cases, requires transfer and exchange of treated water across purveyor service boundaries. The OUs are typically structured to minimize alterations to the total amount of groundwater production throughout the basin. Thus, production rates of new (or existing) OU wells are increased to their maximum capacity or to a specific production rate such that these rates balance the historical production rates of the wells identified to be taken out of service or at which production will be substantially reduced (shut-down wells). The first set of shut-down wells selected for each OU are those nearest downgradient from the OU wells. As more are needed to balance excess production, additional downgradient wells, located at increasing distances from the OU wells, are selected to be shut down. In a few OUs, wells upgradient are also shut down to maintain a balanced rate of production. For a majority of the 39 quarter-years simulated with the numerical model of groundwater flow and contaminant transport (Appendix C), the total volume of reduced pumping in the shut-down wells balances OU production rates. However, in periods of high demand, OU production rates may need to be supplemented with periodical pumping of the shut-down wells. Additional information on this subject is provided in Appendix C.

D.1.2 TARGET TREATMENT LEVELS

Superfund Amendments and Reauthorization Act (SARA) guidance proposes that a range of treatment criteria be considered in remedial action alternatives. Applicable and Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) criteria provide the treatment criteria. To comply with ARARs, both federal and state MCLs have to be promulgated. Table D-2 lists target treatment levels for various contaminants. The appropriate source for each standard given is also listed in the table. For a number of contaminants, MCLs are currently under review; and the proposed levels are listed. For compounds for which there is no MCL, other standards are listed for comparative purposes. These include California Action Levels (ALs), and Federal Health Advisories. Detailed design of treatment facilities is not within the scope of this Basinwide Plan. The above information is included primarily to identify target treatment levels that will impact the cost and design of the selected treatment process.

D.1.3 TREATMENT TECHNOLOGIES FOR VOC REMOVAL FROM GROUNDWATER

A detailed discussion of treatment technologies is presented in the Whittier Narrows Operable Unit Feasibility Study (OUFS) (EPA, 1989). Based on a review of available physical and chemical treatment technologies, the most viable technologies for removal of VOCs from groundwater include: packed tower air stripping, granular activated carbon (GAC), and advanced oxidation. Table D-3 describes the relative applicability of each technology to treat VOCs in the San Gabriel Basin groundwater. Where considered applicable, nitrates will also be treated. In later sections, tables that describe treatment and distribution requirements for each OU indicate whether nitrate contamination is expected to exceed MCLs. Nitrate treatment technologies are described in Appendix E. Evaluation and selection of a specific treatment process for each OU will be addressed in much more detail in an FS completed prior to implementation.

D.1.4 TREATMENT FACILITY SIZING AND SITING CRITERIA

Siting of treatment plants has a direct impact on the water distribution system. An effort has been made to site treatment plants at a location central to the extraction (OU) wells, minimizing pump and pipeline cost. The current treatment plant locations are used to estimate the approximate length of pipelines required to convey extracted water to treatment facilities and redistribute the treated water to the shut-down wells. These locations are approximate and the exact location will be determined in the course of conducting FSs for each of the individual OUs. In these studies, the following siting considerations must be evaluated:

TABLE D-2
TARGET TREATMENT LEVELS
(All values in ppb)

Contaminants	Treatment Level	Source of Regulation
PCE	5	Cal MCL
TCE	5	Cal MCL
Carbon Tetrachloride	0.5	Cal MCL
1,1,1-TCA	200	Cal MCL
1,1-DCA	5	Proposed MCL
1,1-DCE	6	Cal MCL
cis-1,2-DCE	6	Proposed MCL
trans-1,2-DCE	10	Proposed MCL
1,2-DCA	0.5	Cal MCL
1,1,2,2-TCA	1	Cal MCL
Acetone	na	
Benzene	1	Cal MCL
Ethylbenzene	680	Cal MCL
Methylene Chloride	5	Proposed MCL
Toluene	0.5	Cal MCL
Total Xylenes	1,750	Cal MCL
Vinyl Chloride	0.5	Cal MCL
MEK	200	HEA ADV
Bromoform*	100	MCL
Dibromochloromethane*	100	MCL
Chloroform*	100	MCL
Freon 113	18,000	Cal Al

Explanation
ppb = parts per billion
na = no standard available
Cal AL = California Action Level
MCL = Maximum Contaminant Level
HEA ADV = Federal Health Advisories

*Trihalomethanes are not to exceed a combined total of 100 ppb.

TABLE D-3
RELATIVE APPLICABILITY OF TECHNOLOGIES TO TREATMENT
OF SAN GABRIEL GROUNDWATER

Contaminants	Stripping Efficiency	Adsorption Efficiency	Oxidation Rate[a]
PCE	Good	Good	Fast
TCE	Good	Good	Fast
Carbon Tetrachloride	Good	Good	Very Slow
1,1,1-TCA	Good	Good	Moderate
1,1-DCA	Good	Good	Moderate
1,1-DCE	Good	Good	Fast
cis-1,2-DCE	Good	Good	Fast
trans-1,2-DCE	Good	Good	Fast
1,2-DCA	Ok	Good	Moderate
1,1,2,2-TCA	Ok	Good	Moderate
Acetone	Poor	Poor	Moderate
Benzene	Good	Good	Fast
Ethylbenzene	Good	Good	Fast
Methylene Chloride	Good	Good	Slow
Toluene	Good	Good	Fast
Total Xylenes	Good	Good	Fast
Vinyl Chloride	Good	Poor	Fast
MEK	Poor	Poor	Moderate
Bromoform	Good	Ok	Moderate
Dibromochloromethane	Good	Ok	Moderate
Chloroform	Good	Ok	Moderate
Freon 113	Good	Good	Very Slow

[a]Rates are estimated and must be confirmed during pilot testing.

- Existing development
- Right-of-way
- Land-use restrictions
- Community acceptance
- Centralized or decentralized plants
- New pipelines required to convey water from extraction wells to treatment plants and distribution of treated water to replace shut-down wells

Treatment plants were sized to handle the estimated peak summer water demand. A factor of two was used to estimate the peak daily demand from the known peak quarterly demand. Peak hourly demands are assumed to be regulated by existing reservoir operation. For conditions beyond these typical scenarios, it is assumed the shut-down wells can be temporarily turned on to help supplement any additional need for water.

D.1.5 PIPELINE ASSUMPTIONS

As discussed earlier, the estimates of pipeline needs do not fully consider existing water distribution networks because of the lack of information on existing pipeline design, present conditions, operation, ownership, and other related parameters. The following assumptions apply to the size and locations of the pipelines:

1. In the first alternative, existing pipelines are assumed capable of having sufficient extra carrying capacity to transmit treated water from OU pipelines to purveyors' service areas. In areas lacking existing pipeline data or having pipelines less than 12 inches in diameter, OU pipelines are taken to the boundary of purveyors' service areas.

2. In the second alternative, existing pipelines are assumed not to have any additional carrying capacity and treated water is delivered directly to the shut-down wells.

3. To provide sufficient pressure head, pipeline pressures of 90 pounds per square inch (psi) are assumed for all pipelines connecting into purveyor lines.

4. Pipeline sizes are based on simulated period peak flows used as withdrawal rates from extraction wells and reduced or eliminated pumpage from wells that are shut down.

5. The maximum quarterly demand is used to estimate maximum daily peak flow assuming that peak hourly demand will be met by the existing system's reservoir storage.

6. Pipeline size is based on an estimated flow velocity of 5 feet per second (fps) to minimize turbulent flow headloss.

7. Approximate pipeline layouts parallel existing major pipelines, wherever possible, to:

   - o Reduce potential easement conflicts
   - o Ease ownership and maintenance conflicts
   - o Minimize the number of purveyors per distribution line

8. New pipeline layouts are placed so as to minimize expensive river and highway crossings.

D.2.0 ANALYSIS OF REPRESENTATIVE OPERABLE UNITS

D.2.1 OPERABLE UNIT 1E

The primary objective of OU 1E is to reduce and control contaminant migration from the major zone of contamination in the northwest region of Area 1. Operable Unit 1E consists of two existing wells pumped at capacity with a combined total production of 1,184 ac-ft/qtr. These wells are within an area contaminated above 25 micrograms per liter (ug/l). Figure C-5 is a graph of recommended production compared to the actual production simulated with the numerical model. Figures D-1 and D-2 show the locations of the OU wells, and proposed pipeline locations for the two alternative scenarios described previously. Service areas corresponding to individual water purveyors are coded by number in Figures D-1 and D-2, and are identified in Table D-4. Table D-5 lists both extraction and shut-down wells, by owner.

Table D-4
WATER PURVEYOR CODES

Code	Producer's Name	Code	Producer's Name
0	None Reported	23	County of Los Angeles
1	Adams Ranch Mutual	24	Los Flores Mutual
2	City of Alhambra	25	Maple Water
3	Amarillo Mutual	26	City of Monrovia
4	City of Arcadia	27	City of Monterey Park
5	City of Azusa	28	City of Pasadena
6	Azusa Valley	29	Richwood Mutual
7	Baseline	30	Rowland Area County
8	Beverly Acres Mutual	31	Rurban Homes Mutual
9	Cal-American - Duarte	32	San Gabriel County
10	Cal-American - San Marino	33	San Gabriel Valley
11	California Domestic	34	City of Sierra Madre
12	Cedar Avenue Mutual	35	Southern California - San Dimas
13	Champion Mutual	36	Southern California - San Gabriel Val.
14	City of Covina	37	City of South Pasadena
15	City of Industry	38	Suburban Water Systems
16	Del Rio Mutual	39	Sterling Mutual
17	East Pasadena	40	Sunny Slope
18	City of El Monte	41	Valencia Heights
19	City of Glendora	42	Valley County
20	Hemlock Mutual	43	Valley View Mutual
21	La Puente Valley County	44	Walnut Valley
22	City of La Verne	45	City of West Covina

Wells that are shut down are both downgradient and upgradient of the OU extraction wells. One of the OU wells, 1903097, is owned by the City of Alhambra, which also owns nine of the shut-down wells. (Well recordation identifiers for the OU wells are identified in Appendices A and C.) Five of these nine wells are downgradient and in the vicinity of well 1903097. Locating a treatment plant close to this well should allow for the redistribution of treatedwater to these five wells using existing pipeline with relatively minor amounts of additional pipeline to accommodate the increased production at the OU well. A second treatment plant is required for OU well 01901681. While this well is owned by the City of South Pasadena, the shut-down wells, except well 01901679, are owned by the various owners listed in Table D-5. Some of the shut-down wells are located upgradient of the OU well. Although nitrate concentrations slightly above the nitrate MCL have been detected at one of the IE wells (Table A-1), it is assumed that blending will be used to maintain treated water below the MCL. Thus, nitrates are listed below 45 ppm in Table D-6, and only VOC treatment is anticipated to be required at OU 1E.

Thus, the first distribution alternative for OU 1E, shown in Figure D-1, is predominantly made up of pipeline from the wells to treatment plants, with some additional 12- and 18-inch-diameter pipelines supplementing the existing network. The second distribution alternative, shown in Figure D-2, includes much more pipeline interconnecting the treatment facilities with the shut-down wells. Detailed analyses of the current pipeline network may reveal that it is inadequate for redistributing the total capacity of treated water from these facilities to service areas. The second alternative includes new pipelines to distribute treated water to the currently producing wells, from which the water can be routed to service areas as at present.

These and various other alternatives will be carefully considered based on presently unavailable data regarding the details of supply, demand, and distribution of water, prior to the design of this OU. At present, the pipeline networks shown in Figures D-1 and D-2 will be assumed for comparative and cost estimating purposes. Table D-6 summarizes the approximate size of treat-ment plants and estimated total pipeline lengths.

D.2.2 OPERABLE UNIT 2J

The objective of OU 2J is to remove contaminants and control migration from the largest zone of contamination in Area 2. This OU consists of three new wells with a combined capacity of 3,600 ac-ft/qtr. The OU wells are located at the downgradient edge of the large 25 ug/l zone of contamination in Area 2. The total OU production rate has been set at 3,460 ac-ft/qtr to balance existing production at downgradient wells. Figure C-9 and Table C-3 show the simulation production rates in each OU as a function of time. Figures D-3 and D-4 show the distribution of OU extraction wells, shut-down wells, and proposed pipeline alignments, and Table D-7 lists the owners of these wells.

The three OU wells are within one-half mile of one another. Considering the relative closeness of these wells, one treatment facility is proposed for treatment of extracted water from all three OU wells. The shut-down wells are both upgradient and downgradient of the OU wells. The proposed distribution

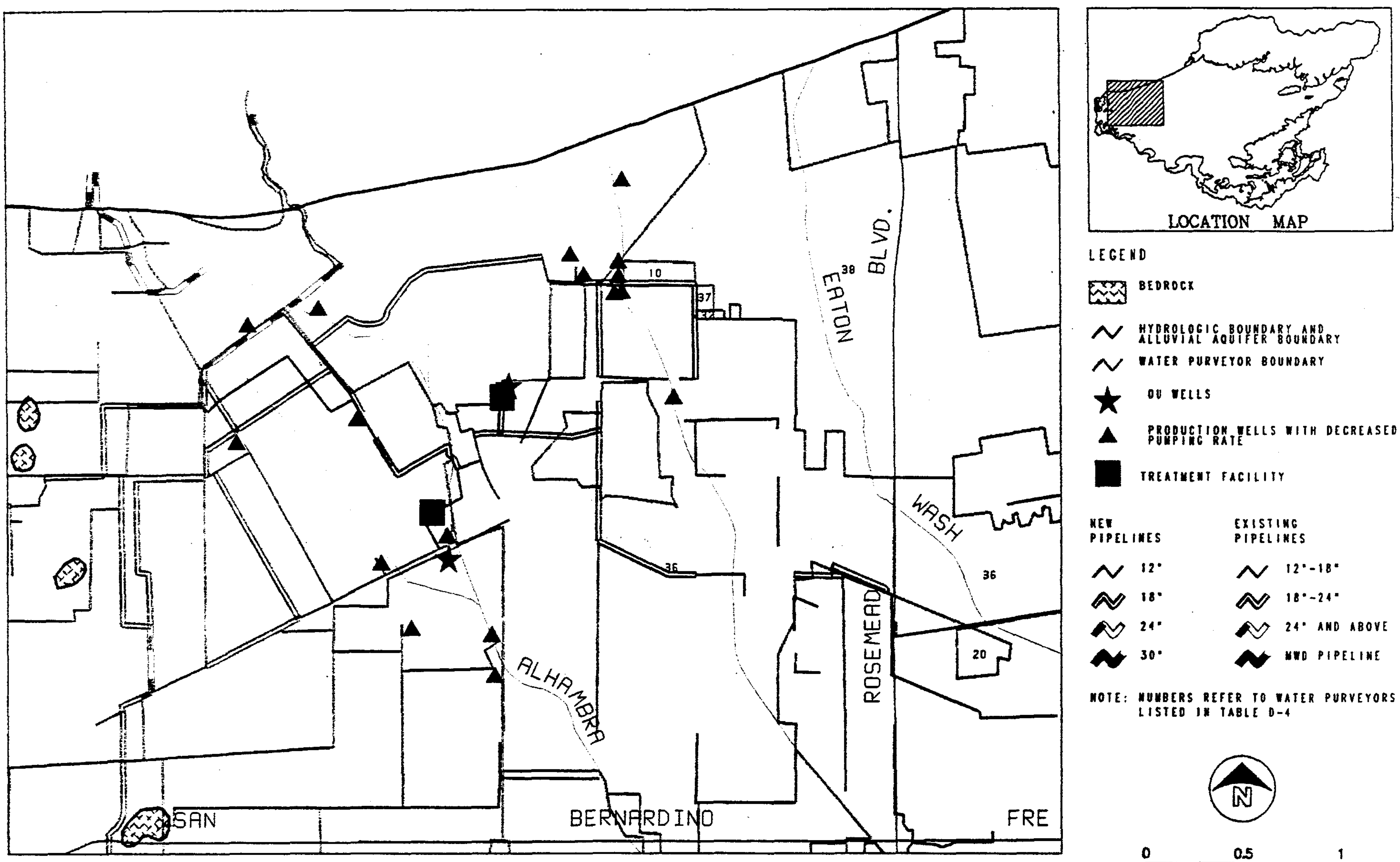

FIGURE D-1
WATER SUPPLY AND DISTRIBUTION
OU1E - FIRST ALTERNATIVE

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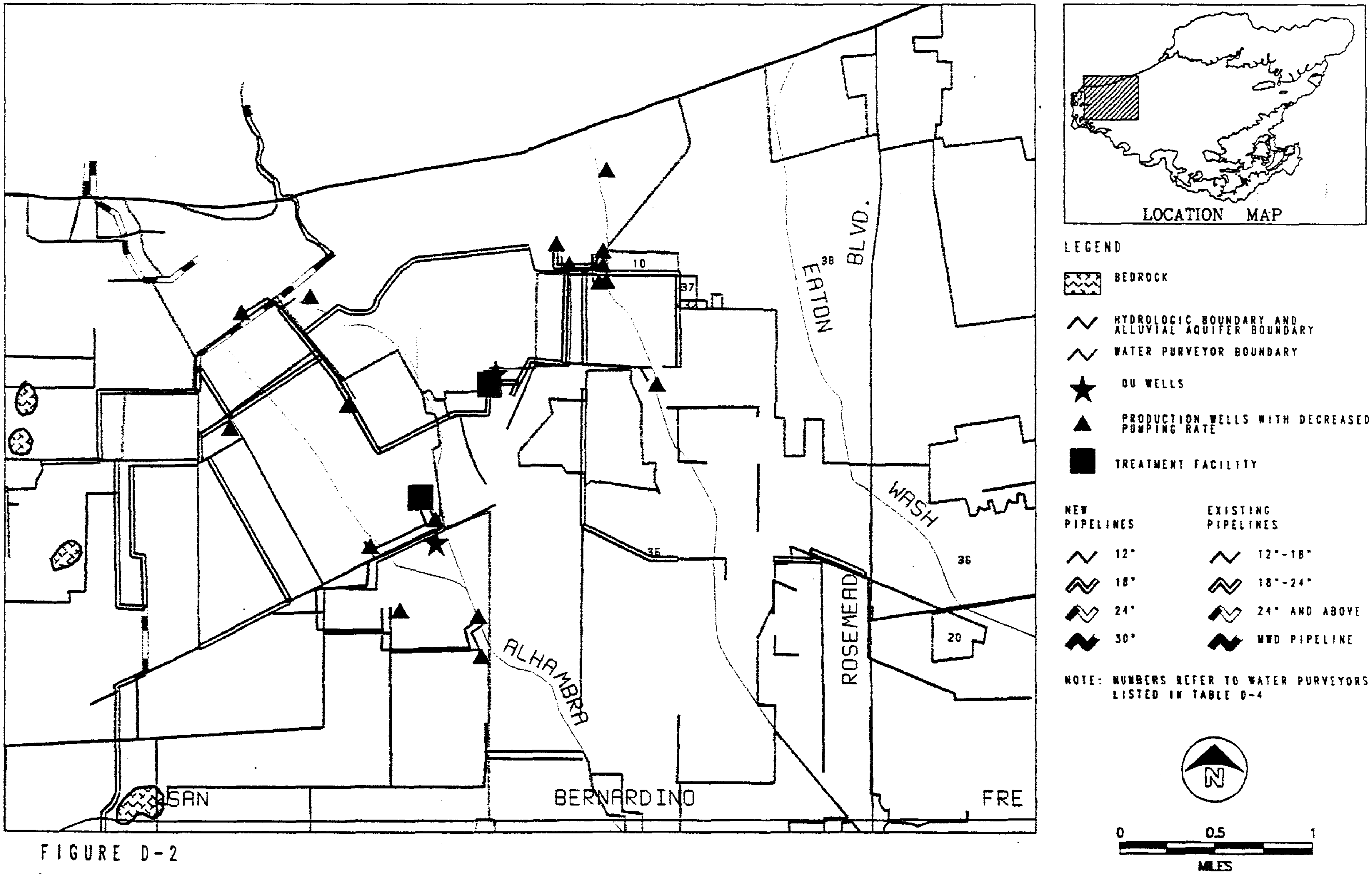

FIGURE D-2

WATER SUPPLY AND DISTRIBUTION

OU1E - SECOND ALTERNATIVE

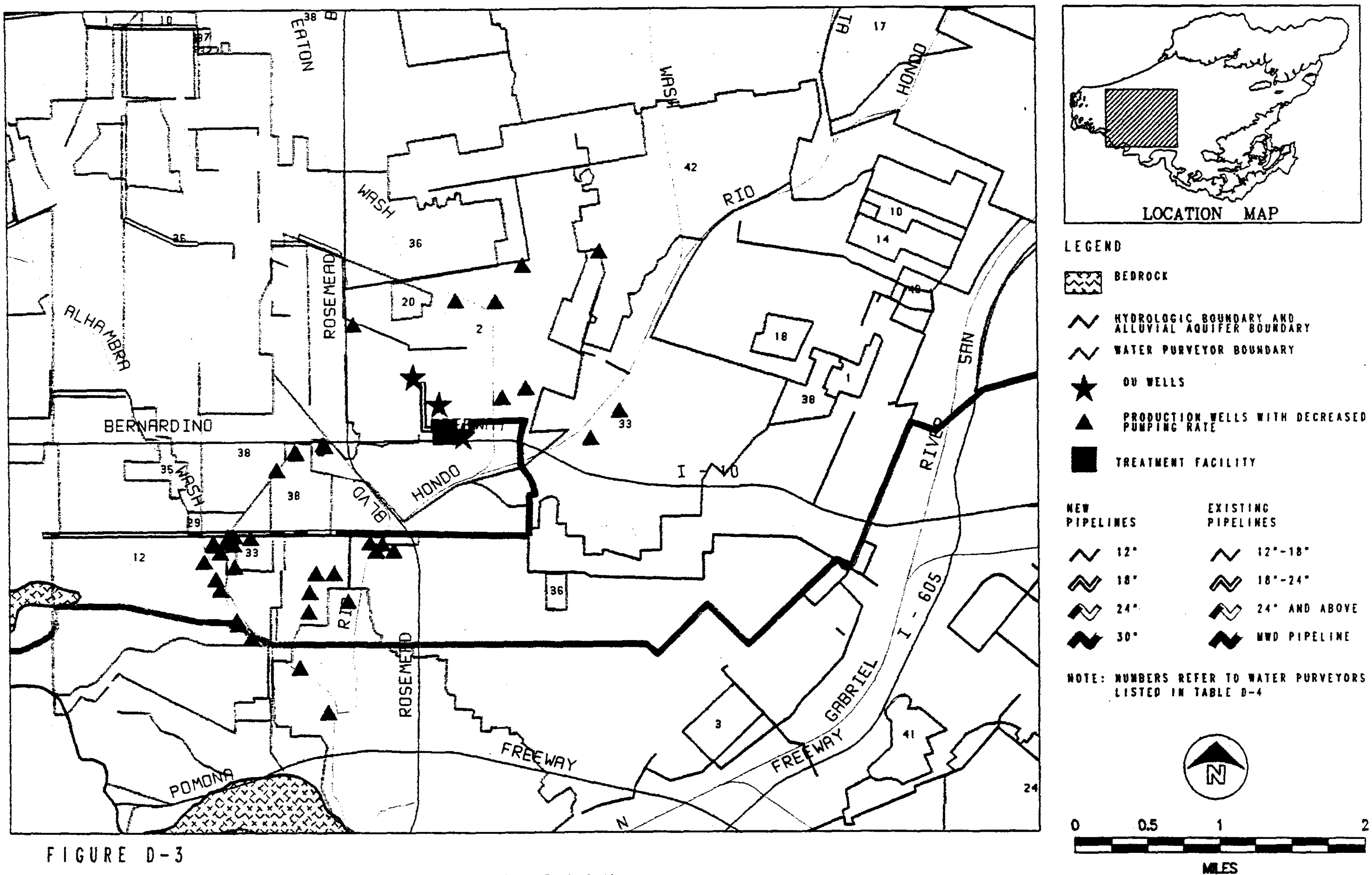

FIGURE D-3

WATER SUPPLY AND DISTRIBUTION

OU2J - FIRST ALTERNATIVE

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San Gabriel Basin

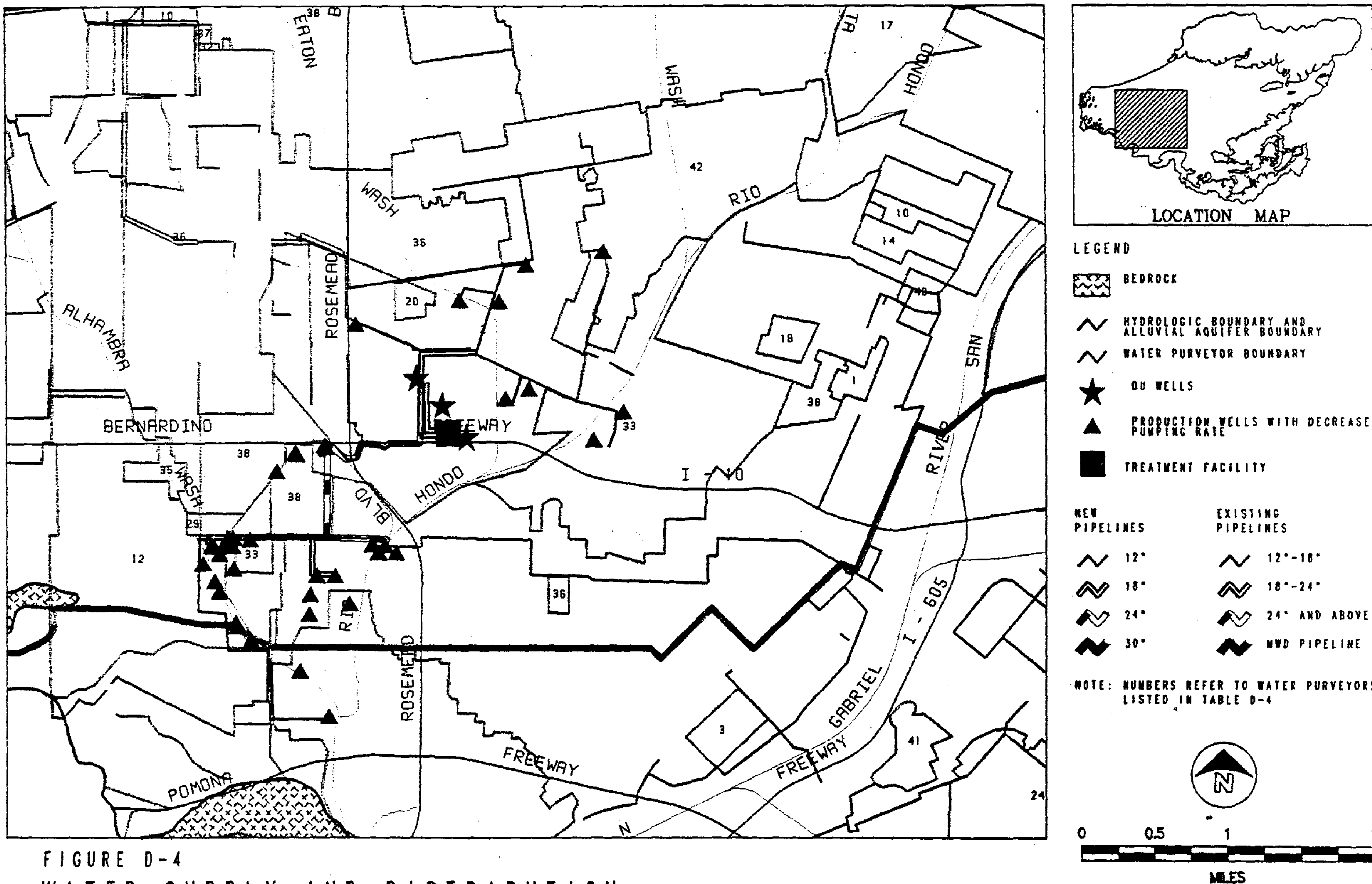

FIGURE D-4

WATER SUPPLY AND DISTRIBUTION

OU2J - SECOND ALTERNATIVE

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San Gabriel Basin

Table D-5
OU 1E WELL OWNERSHIP DISTRIBUTION

Purveyor/Owner	Number of Wells	Well Recordation Number
Extraction Wells		
Alhambra	1	01903097
South Pasadena	1	01901681
Shut-Down Wells		
Alhambra	9	01900010, 1900011, 01900012, 01900013, 01900014, 01900015 01900017, 01900018, 01902789
Cal American Water	3	01900935, 01900934, 01903059, 01901441, 01902787, 01902424
South Pasadena	1	01901679
San Gabriel County Water	2	01901671, 01902785
San Gabriel Country Club	2	01902979, 01900547,

Table D-6
ESTIMATED PIPELINE LENGTHS AND TREATMENT PLANT CAPACITY REQUIREMENTS FOR OU 1E

Pipe Line (inches)	Length (feet)	River Crossings	Highway Crossings	Treatment Plant Number	Size (gpm)	VOC Concentration (ppb)	Nitrate Concentration (ppm)
Alternative No. 1							
12	13,950	2	0	1	1,500	25	<45
18	8,200	1	0	2	1,500	25	<45
Alternative No. 2							
12	21,000	3	0	1	1,500	25	<45
18	15,000	1	0	2	1,500	25	<45

pipelines parallels the existing pipeline, where possible. In areas where existing pipelines have not been identified, proposed pipelines generally follow existing roads. The high concentration of shut-down wells near Alhambra Wash assisted in minimizing pipeline lengths. Table D-8 summarizes the assumed pipeline and treatment facility requirements.

Pipelines proposed for the first alternative (Figure D-3) include 12- and 18-inch-diameter pipes to distribute water from the wells to the treatment facility, and pipes up to 30 inches in diameter to distribute treated water to the existing distribution system within purveyor boundaries. In the second alternative

Table D-7
OU 2J WELL OWNERSHIP DISTRIBUTION

Purveyor/Owner	Number of Wells	Well Recordation Number
Extraction Wells		
New Wells	3	2J000001, 2J000002, 2J000003
Shut-Down Wells		
San Gabriel Valley Water	5	31903101, 31900747, 31900736, 31900746,01900725
Cal American Water - San Marino	6	01900923, 01902867, 01900918, 01901441, 01902787, 01902424
Amarillo Mutual Water Company	2	01900791, 01900792
Los Angeles County	3	01902665, 01902666, 01902663
Monterey Park	12	01903033, 01902372, 01902373, 01902690, 01900454, 01900455, 01900453, 01902828, 01900457, 01900456, 01903092, 01900458
Southern California Water	6	01902144, 01900513, 01900512, 01900510, 01900511, 01902020
Southern California Edison	2	11900344, 21900344
El Monte	2	01903137, 01901693
Clayton Manufacturing Company	1	01901055
Crown City Plating Company	1	08000012

Table D-8
ESTIMATED PIPELINE LENGTHS AND TREATMENT PLANT CAPACITY REQUIREMENTS FOR OU 2J

Pipe Line (inches)	Length (feet)	River Crossings	Highway Crossings	Treatment Plant Number	Size (gpm)	VOC Concentration (ppb)	Nitrate Concentration (ppm)
Alternative No. 1							
12	3,900	0	0	1	10,000	25	<45
18	12,400	1	0				
24	2,900	0	0				
30	14,300	2	2				
Alternative No. 2							
12	29,000	2	0	1	10,000	25	<45
18	13,000	0	0				
24	11,000	2	1				

(Figure D-4), considerably greater lengths of pipeline are required to distribute the water from the treatment facility to each of the shut-down wells.

D.2.3 OPERABLE UNIT 2BCFK

The objective of OU 2BCFK is to utilize one new well and 14 existing wells to remove contamination within Area 2 at a recommended overall rate of 11,542 ac-ft/qtr (Appendix A). Figures D-5 and D-6 show the location of OU and shut-down wells and the two alternate pipeline requirement scenarios. Table D-9 lists extraction and shut down wells by owner. Considering the large area covered by the shut-down wells, redistribution of treated water requires crossing several purveyor boundaries, and interconnecting extraction wells with shut-down wells may require substantial construction of new pipelines.

The OU wells are clustered in two locations within Area 2. Wells in clusters 2B and 2C are in the northeast part of Area 2 within the area contaminated above 25 ug/l. Wells in clusters 2F and 2K are in the southeastern portion of Area 2, also within the 25 ug/l area of contamination. Considering the distribution of extraction well locations, two potential sites for treatment facilities are proposed (Figures D-5 and D-6). A large treatment facility (23,750 gpm [gallons per minute]) is proposed in the vicinity of the northern clusters 2B and 2C. These clusters include several existing production wells with existing pipelines that serve areas north of the OU. No shut-down wells are north of the 2B and 2C clusters. Nitrate concentrations above the MCL have been detected at some of the 2B, 2C, and 2F wells. However, the overall extent of nitrate contamination above the MCL in Area 2 is thought to be limited, and the anticipated method of addressing the nitrate contamination is through blending.

Estimated pipeline lengths and treatment facility sizes for both alternatives are summarized in Table D-10. The new pipeline layout for the first alternative is shown in Figure D-5. Because of the large number of wells involved, considerable pipeline is required just to deliver the water to centralized treatment facilities, and, from there, to purveyor service areas. In the second alternative, new pipeline connects wells south and west of the OU with a second, much smaller (4,800 gpm) treatment facility proposed for clusters 2F and 2K. As seen in Table D-10 and Figure D-6, delivery of treated water to shut-down wells east and west of clusters 2B and 2C requires extensive new pipeline.

D.2.4 OPERABLE UNIT 4K

The objective of OU 4K is to manage the migration of contaminants from Area 5 and 6 into Area 4. The production capacity of the three OU wells is approximately 2,525 ac-ft/qtr. These wells are within the area of groundwater

Table D-9
OU 2BCFK WELL OWNERSHIP DISTRIBUTION

Purveyor/Owner	Number of Wells	Well Recordation Number
Extraction Wells		
Monrovia	4	01900420, 01900419, 01900417, 01900418
Southern California Water	6	01902019, 01902017, 01902018, 01902032, 01902031, 01902020
New Well	1	2K000001
Arcadia	2	01901014, 01901013
California American Water - Duarte	1	01900356
El Monte	1	01901695
Shut-Down Wells		
Southern California Water	5	01902948, 01900514, 01900515, 01902034, 01902027
Arcadia	5	01902854, 01902791, 01902077, 01902078, 01901015
Monrovia	1	01940104
Southwest Suburban Water Systems	1	01901434
San Gabriel County Water	3	08000067, 01901669, 01901670
California American Water - San Marino	8	01903019, 01900925, 01900918, 01900923, 01902867, 01900920, 01900921, 01900926
Alhambra	1	01900016
Amarillo Mutual Water Company	2	01900791, 01900792
El Monte	3	01903137, 01901693, 01901692
San Gabriel Valley Water	8	01900725, 31903103, 31900747, 31900736, 31900746, 28000065, 21900749, 21902857
Los Angeles County	2	01902665, 01902664
Monterey Park	5	01903033, 01902372, 01902373, 01902690, 01900457
Driftwood Dairy	1	01902924
Livingston-Graham, Inc.	3	01901493, 01901492, 01903006
Sully-Miller Contracting	1	01903062
California American Water - Duarte	1	01900355
Sunny Slope Water Company	1	08000048
East Pasadena Water Company	1	11901508
Owl Rock Products	1	01900043

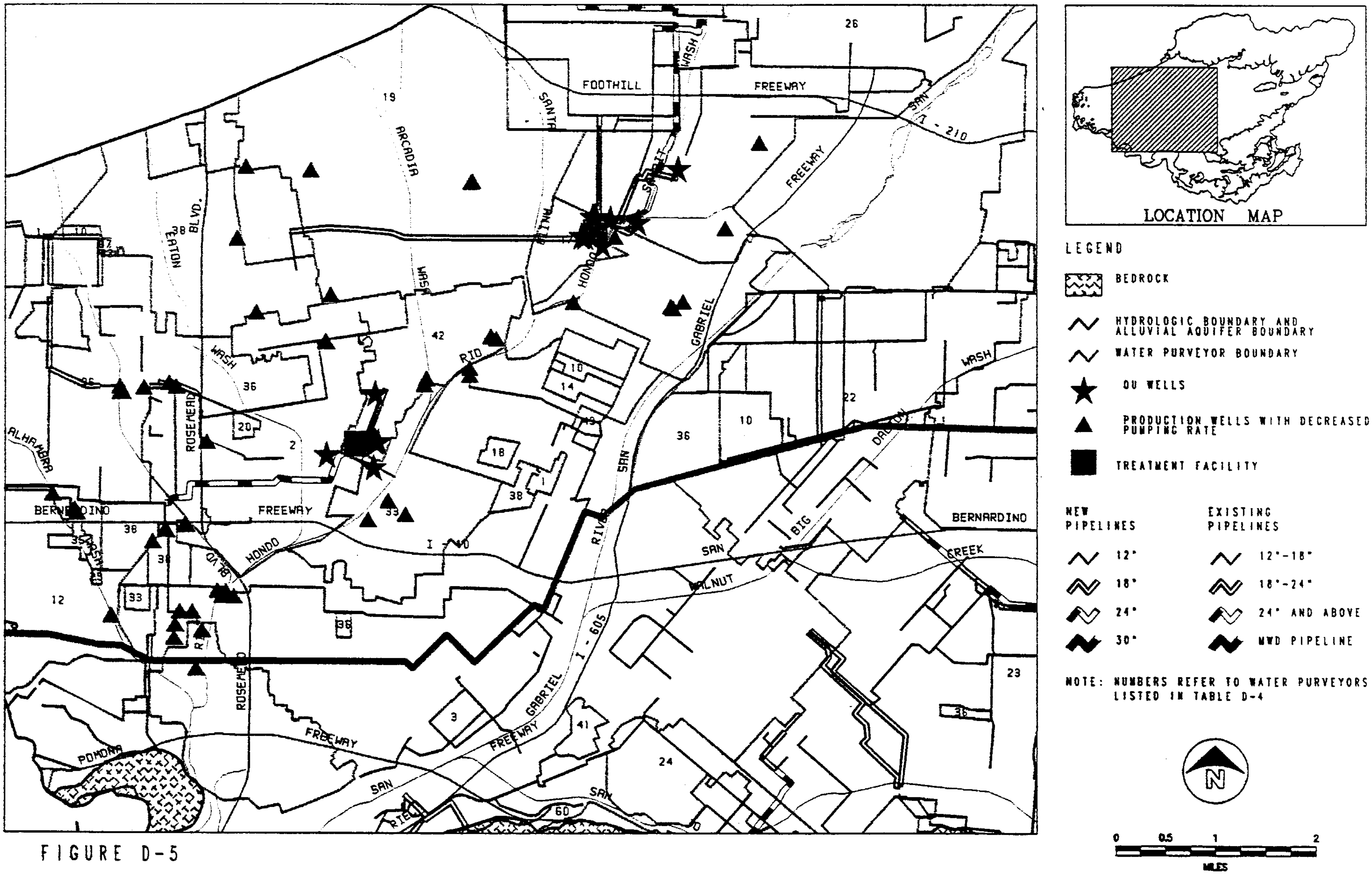

FIGURE D-5

WATER SUPPLY AND DISTRIBUTION

OU2BCFK - FIRST ALTERNATIVE

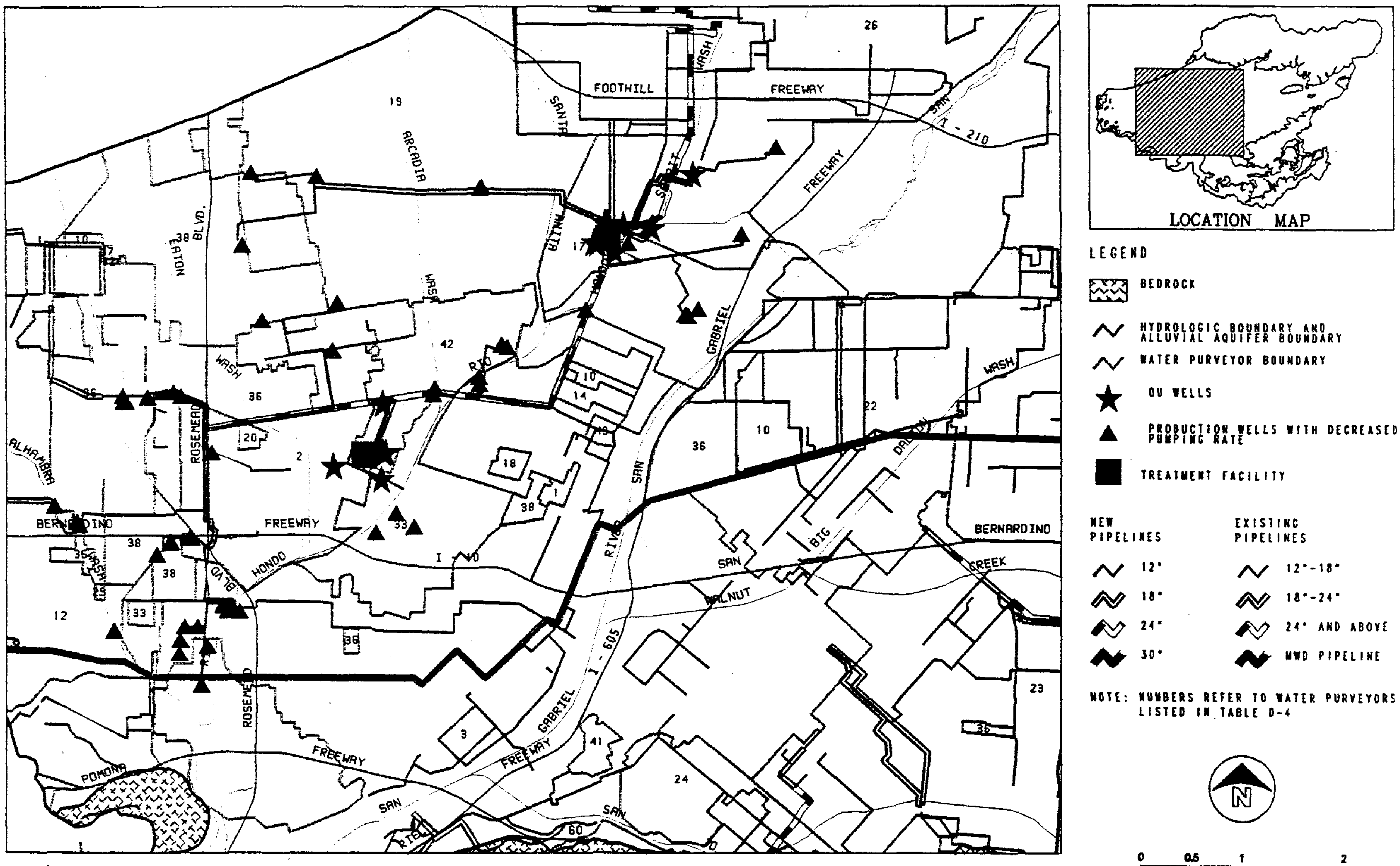

FIGURE D-6

WATER SUPPLY AND DISTRIBUTION

OU2BCFK - SECOND ALTERNATIVE

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Table D-10
ESTIMATED PIPELINE LENGTHS AND TREATMENT PLANT CAPACITY REQUIREMENTS
FOR OU 2BCFK

Pipe Line (inches)	Length (feet)	River Crossings	Highway Crossings	Treatment Plant Number	Size (gpm)	VOC Concentration (ppb)	Nitrate Concentration (ppm)
Alternative No. 1							
12	28,600	1	1	1	23,750	25	<45
18	23,300	4	0	2	4,800	25	<45
24	21,850	2	0				
Alternative No. 2							
12	57,000	4	0	1	23,750	25	<45
18	42,000	4	1	2	4,800	25	<45
24	27,000	4	0				

contamination exceeding 25 ug/l. To balance OU production with historical production rates at other wells, production at wells both upgradient and downgradient of the OU is reduced or eliminated. Figures D-7 and D-8 show the location of proposed new pipelines for each of the two alternatives, and Table D-11 lists the owners of wells in this OU.

Two potential treatment facility locations are proposed (Figures D-7 and D-8), one at either end of the three aligned OU extraction wells. In the first pipeline alternative, a total of 31,700 feet of 12- and 18-inch-diameter pipeline is used to deliver the treated water from these two facilities to the existing distribution system. In the second alternative, 21,300 additional feet of pipeline are required to deliver the treated water to each of the shut-down wells. The estimates of required pipeline lengths for both alternatives are summarized in Table D-12.

D.2.5 OPERABLE UNIT 5TUV

OU 5TUV consists of three new wells, each producing 1400 ac-ft/qtr (production capacity totalling approximately 4,242 ac-ft/qtr). The objective of this OU is to remove contamination at depth within Area 5. The OU wells are within the area contaminated above 25 ug/l. The location of these wells is shown along with proposed pipeline alignments for each of the alternatives in Figures D-9 and D-10. Table D-13 lists these wells by owner.

Because all the shut-down wells are downgradient (south) of the OU extraction wells, one potential treatment facility, located at the southernmost OU well is considered suitable, particularly as a central location for the redistribution of treated water. Interconnection of the OU extraction wells with the identified treatment facility requires approximately 4.5 miles of new pipeline. The first alternate pipeline layout (Figure D-9) requires a total of almost 12 miles of pipeline, between 12 and 24 inches in diameter, to deliver water to the treatment facility, and deliver treated water to purveyors' service areas. Pipeline lengths may be reduced somewhat through a more thorough evaluation of the existing distribution system, in the course of conducting an FS to identify more convenient connection points into the existing system.

Table D-11
OU 4K WELL OWNERSHIP DISTRIBUTION

Purveyor/Owner	Number of Wells	Well Recordation Number
New Extraction Wells	3	4K000001, 4K000002, 4K000003
Shut Down Wells		
California Domestic Water	5	01903057, 01903081, 01901181, 08000100, 01901183
San Gabriel Valley Water	7	61900718, 81902635, 81902525, 41900745, 41902713, 41900739
Los Angeles County	3	08000088, 08000089, 01902579
Rose Hills Memorial Park	5	01900132, 11900095, 01902790, 01900052, 01900094
Whittier	5	01901749, 08000071, 01901747, 01901746, 01901745
Walter Green	2	08000028, 08000027
Beverly Acres Mutual Water Company	1	08000004
Del Rio Mutual Water Company	2	01900331, 01900332
California Country Club	2	01903084, 01902529
City of Industry	5	08000097, 01902582, 08000096, 01902581, 08000078
Ward Duck Company	2	01903072, 01902951
Bahnsen & Beckman, Ind.	2	01902949, 01902950

Table D-12
ESTIMATED PIPELINE LENGTHS AND TREATMENT PLANT CAPACITY REQUIREMENTS FOR OU 4K

Pipe Line (inches)	Length (feet)	River Crossings	Highway Crossings	Treatment Plant Number	Size (gpm)	VOC Concentration (ppb)	Nitrate Concentration (ppm)
Alternative No. 1							
12	10,100	1	1	1	3,125	25	>45
18	21,600	0	0	2	3,125	25	>45
Alternative No. 2							
12	21,000	2	1	1	3,125	25	>45
18	32,000	1	4	2	3,125	25	>45

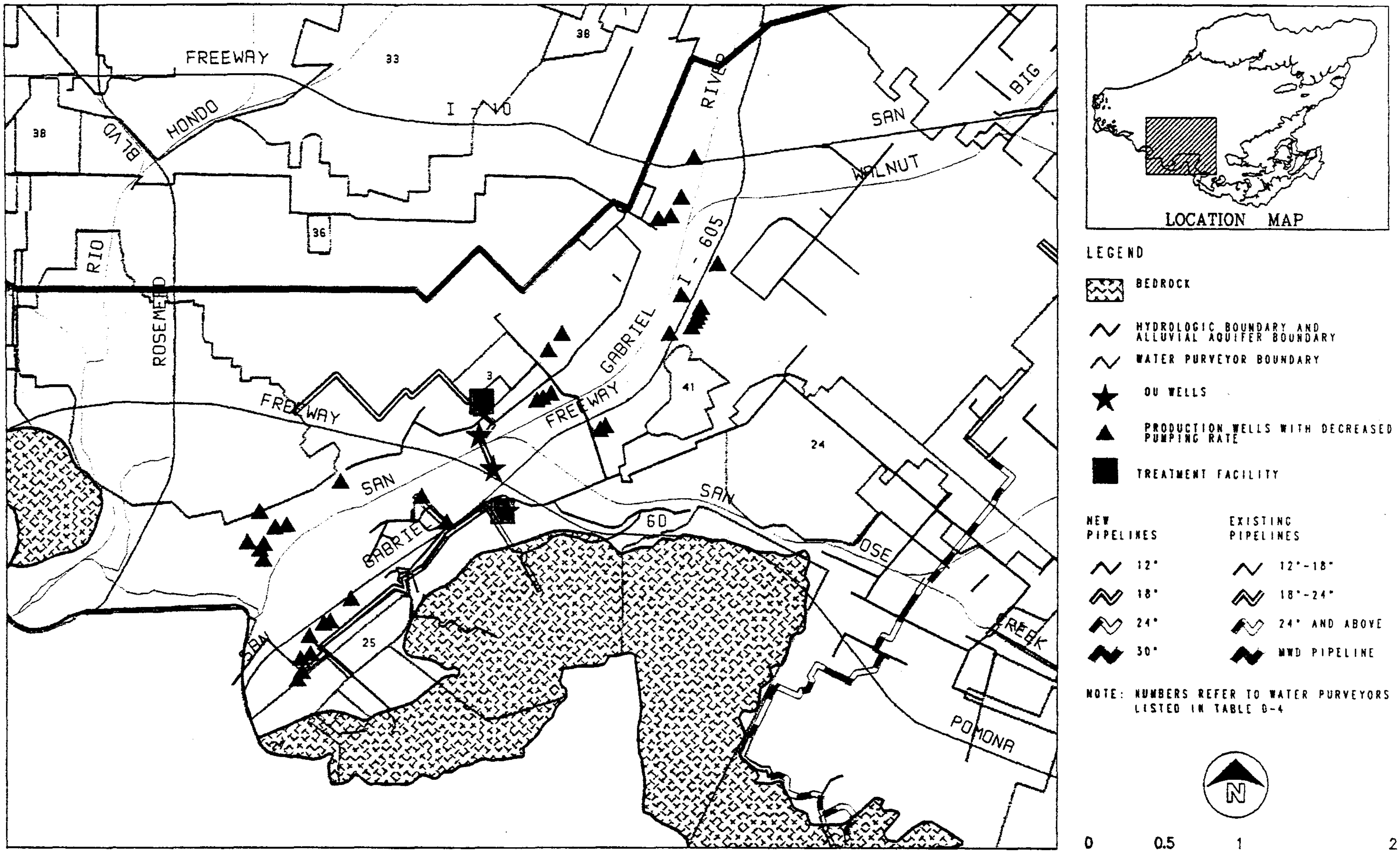

FIGURE D-7

WATER SUPPLY AND DISTRIBUTION

OU4K - FIRST ALTERNATIVE

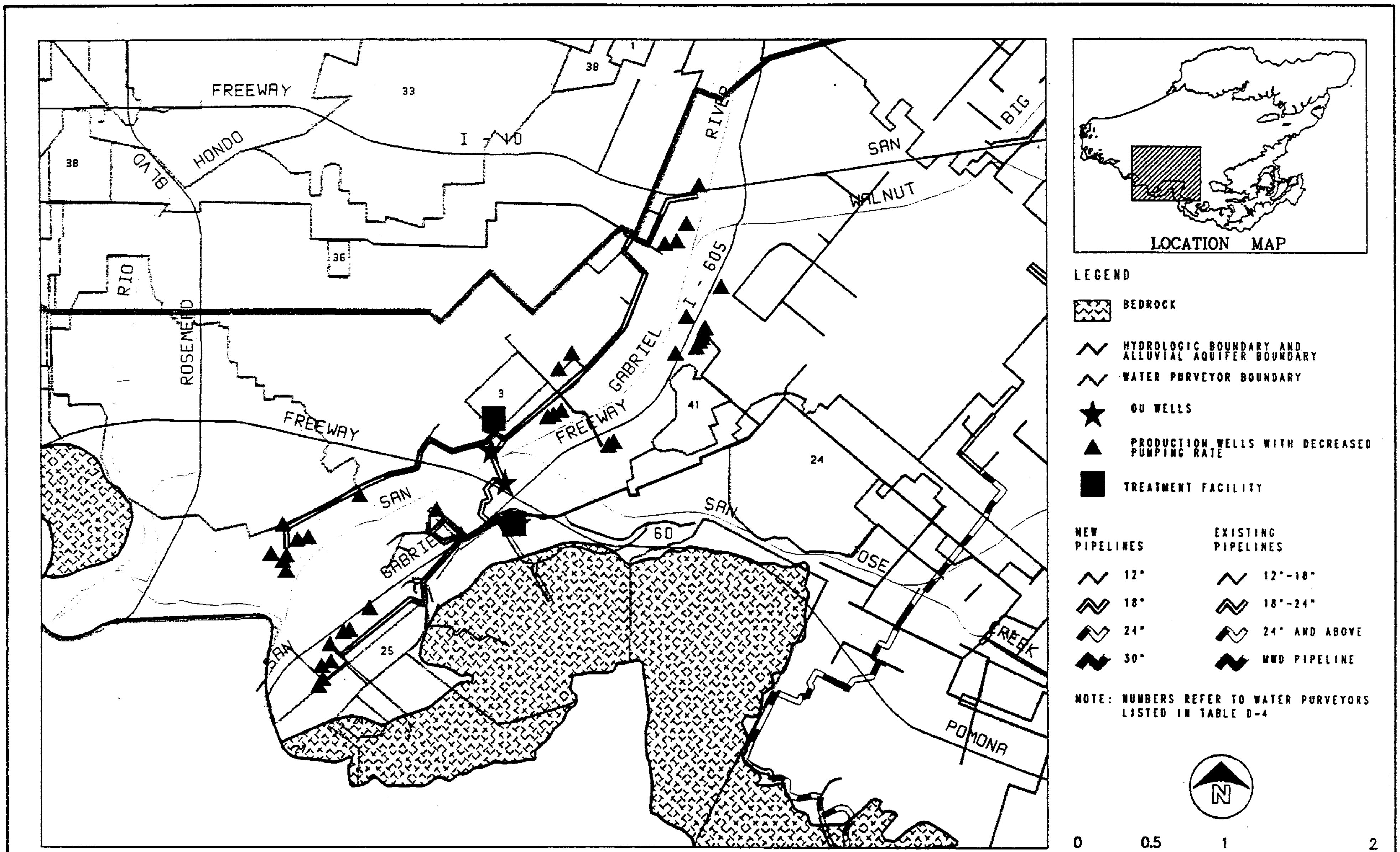

FIGURE D-8

WATER SUPPLY AND DISTRIBUTION

OU4K - SECOND ALTERNATIVE

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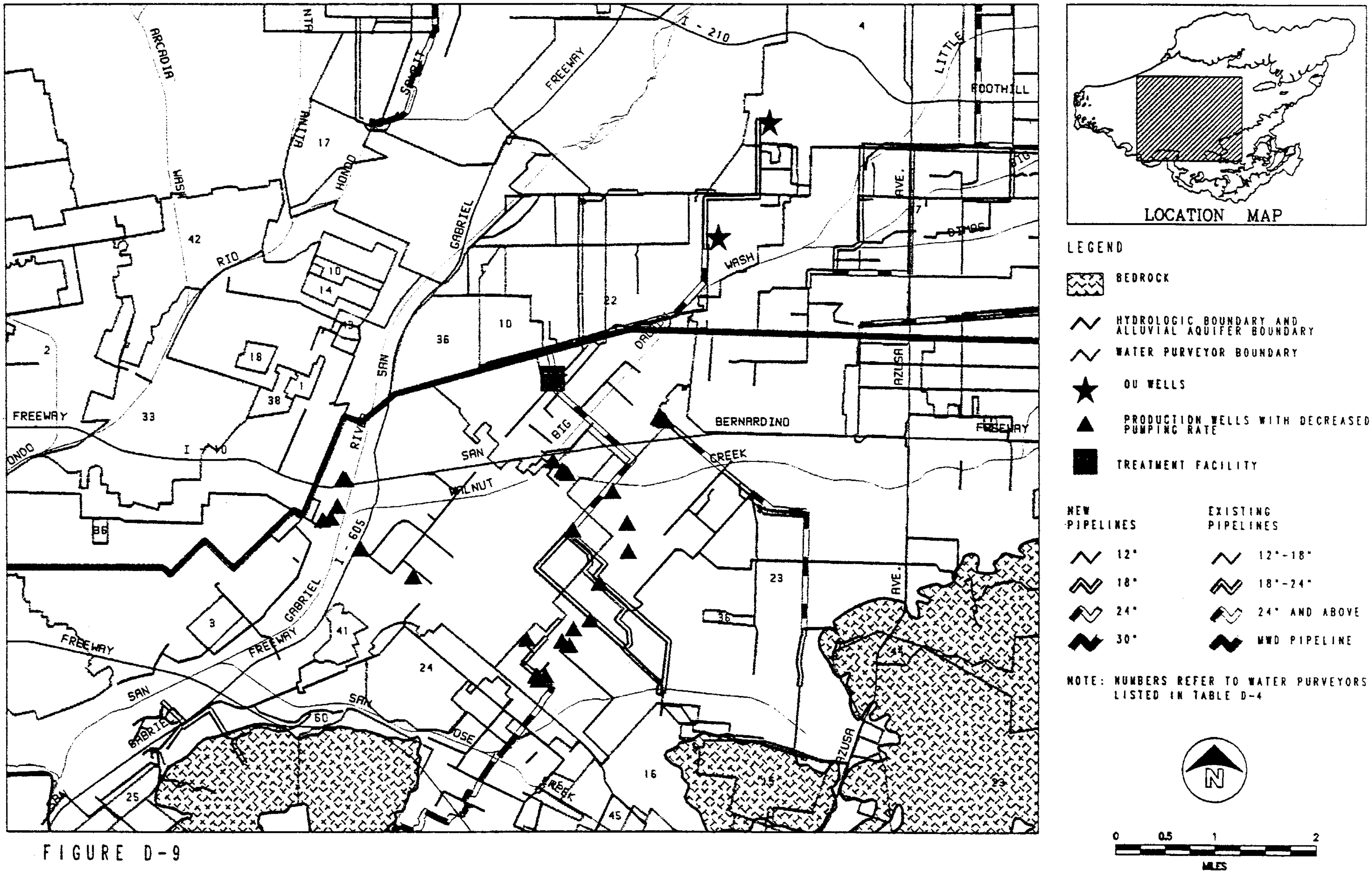

FIGURE D-9

WATER SUPPLY AND DISTRIBUTION

OU5TUV - FIRST ALTERNATIVE

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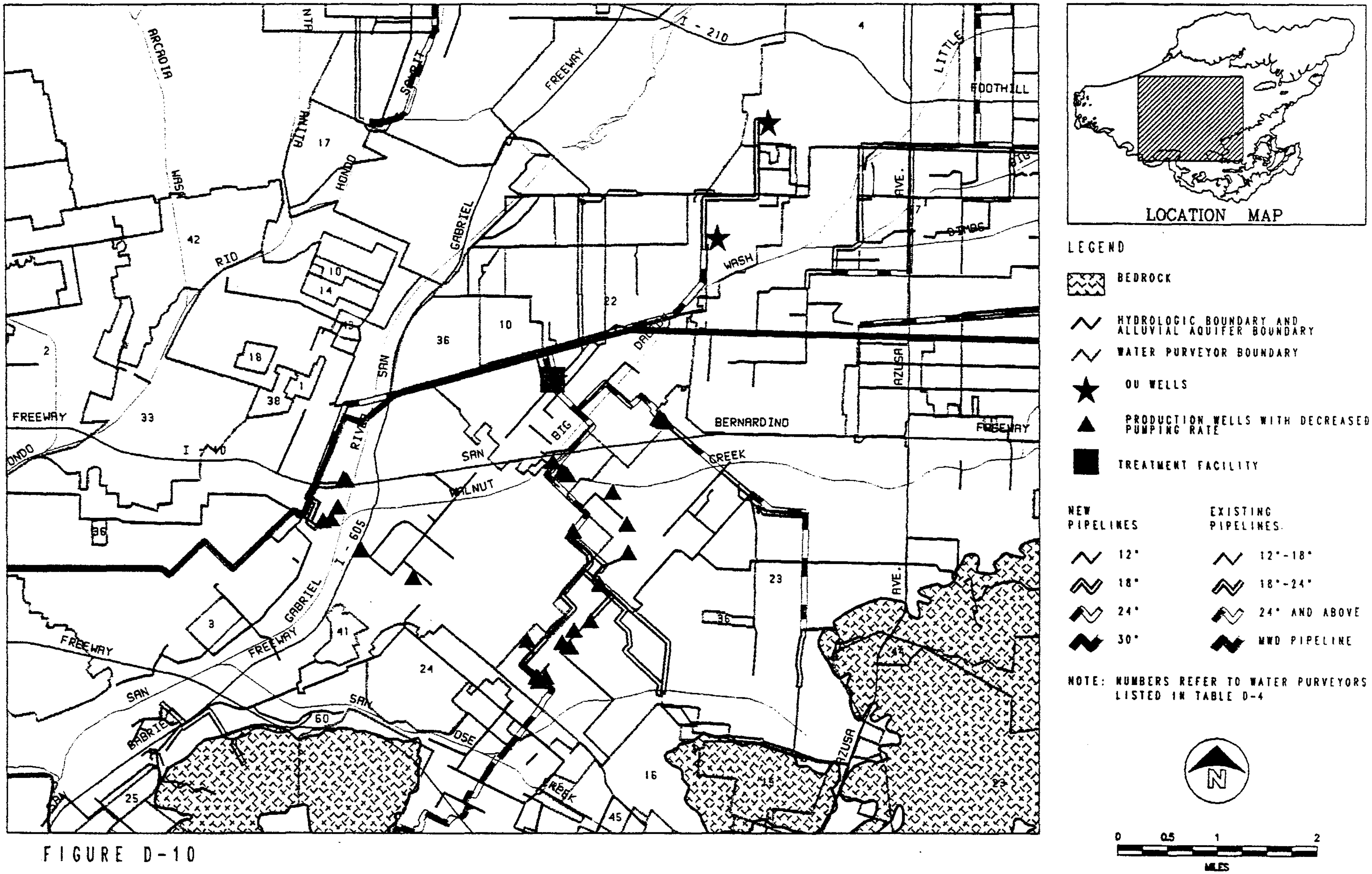

FIGURE D-10
WATER SUPPLY AND DISTRIBUTION
OU5TUV - SECOND ALTERNATIVE

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San Gabriel Basin

Table D-13
OU 5TUV WELL OWNERSHIP DISTRIBUTION

Purveyor/Owner	Number of Wells	Well Recordation Number
New Extraction Wells	3	5T000001, 5U000001, 5V000001
Shut-Down Wells		
Southwest Suburban Water Systems	17	01901598, 01901599, 08000077, 01903067, 08000093, 01901602, 01902119, 08000095, 08000069, 01901600, 01902519, 01901596, 01902760, 01901612
San Gabriel Valley Water	7	91901437, 71903093, 98000094, 98000068, 91901440, 91901435, 61900718
California Domestic Water	6	01902967, 01903057, 01903081, 01901181, 08000100, 01901183
La Puente Valley County Water	3	08000062, 01901460, 01902859
Sonoco Products Company	1	01902971

The second alternative (Figure D-10), in which existing pipelines are assumed to be unavailable, requires a total of about 14 miles of pipeline. To distribute treated water to the shut-down wells, two mains along the existing pipelines (where possible) are proposed. Table D-14 summarizes pipeline lengths and treatment facility size requirements for both alternatives.

Table D-14
ESTIMATED PIPELINE LENGTHS AND TREATMENT PLANT CAPACITY REQUIREMENTS FOR OU 5TUV

Pipe Line (inches)	Length (feet)	River Crossings	Highway Crossings	Treatment Plant Number	Size (gpm)	VOC Concentration (ppb)	Nitrate Concentration (ppm)
Alternative No. 1							
12	4,900	1	0	1	10,000	25	>45
18	31,700	0	0				
24	26,100	0	1				
Alternative No. 2							
12	7,400	0	1	1	10,000	25	>45
18	19,800	0	1				
24	48,800	2	2				

D.2.6 OPERABLE UNIT 5CDGFIJ

The objective of OU 5CDGFIJ, as with 5TUV, is to remove contamination from Area 5 (Figure C-1). This OU is made up of 13 existing wells within the area contaminated above 25 ug/l in Area 5. A combined production rate of 13,139 acre-ft/qtr is recommended in Appendix A. Individual production rates of wells vary from 400 gpm to 4,200 gpm. Because wells shut down downgradient and upgradient of the OU wells do not meet the 13,139 ac-ft/qtr of production at OU wells, OU production is reduced to an average of abount 11,200 ac-ft/qtr. Figure C-18 shows the recommended OU production compared to the actual simulated OU production for the 39 quarters. The locations of extraction and shut-down wells, along with the pipeline alignments proposed for each of the alternatives are shown in Figures D-11 and D-12. The owners of these wells are listed in Table D-15.

The OU extraction wells and shut-down wells are widely distributed throughout Area 5. The area encompassed by the OU is relatively large compared to the other OUs. However, OU extraction wells are also distributed such that treatment of extracted water at three central locations is considered suitable and cost effective. Pipeline sizes, lengths, and treatment facility parameters are listed in Table D-16.

The first distribution alternative for OU 5CDGFIJ, shown in Figure D-11, includes over 12 miles of new pipeline up to 24 inches in diameter to transport water to the three treatment facilities, and to distribute treated water into existing pipelines. Because the two northern treatment facilities are located within the service area of many of the shut-down wells and because of the relative abundance of large pipelines in the area, much of the new pipeline requirements are limited. Extensive pipeline to connect treatment facilities with existing pipelines are required only at the southernmost treatment facility.

Almost 34 miles of pipeline, on the other hand, are required to deliver treated water to each of the shut-down wells, as shown in the second alternative displayed in Figure D-12. Most of these new pipelines parallel existing pipelines, including the MWD feeder which transects the area. The distribution of treated water to shut-down wells is a particularly costly option in the case of OU 5CDGFIJ, as detailed in Appendix E.

D.2.7 OPERABLE UNIT 5W

The objective of OU 5W is to protect a large regional pumping center from contamination downgradient of Area 6, in the southeastern corner of Area 5. The OU uses four new wells, located in Area 5, just upgradient of the pumping center. With a combined production of 10,000 gpm or 4,040 ac-ft/qtr, each well is assigned a recommended production of 2,500 gpm. These wells are within the greater than 25 ug/l contamination zone. To balance the extraction rates with the historical pumping volumes at available shut-down wells, OU production is reduced to approximately 3,850 ac-ft/qtr. Figure C-21 shows recommended OU production compared to simulated OU production for the 39 quarters simulated in the numerical model. Figures D-13 and D-14 show the locations of extraction and shut-down wells, along with the two alternate pipeline layouts. Table D-17 lists the owners of these wells.

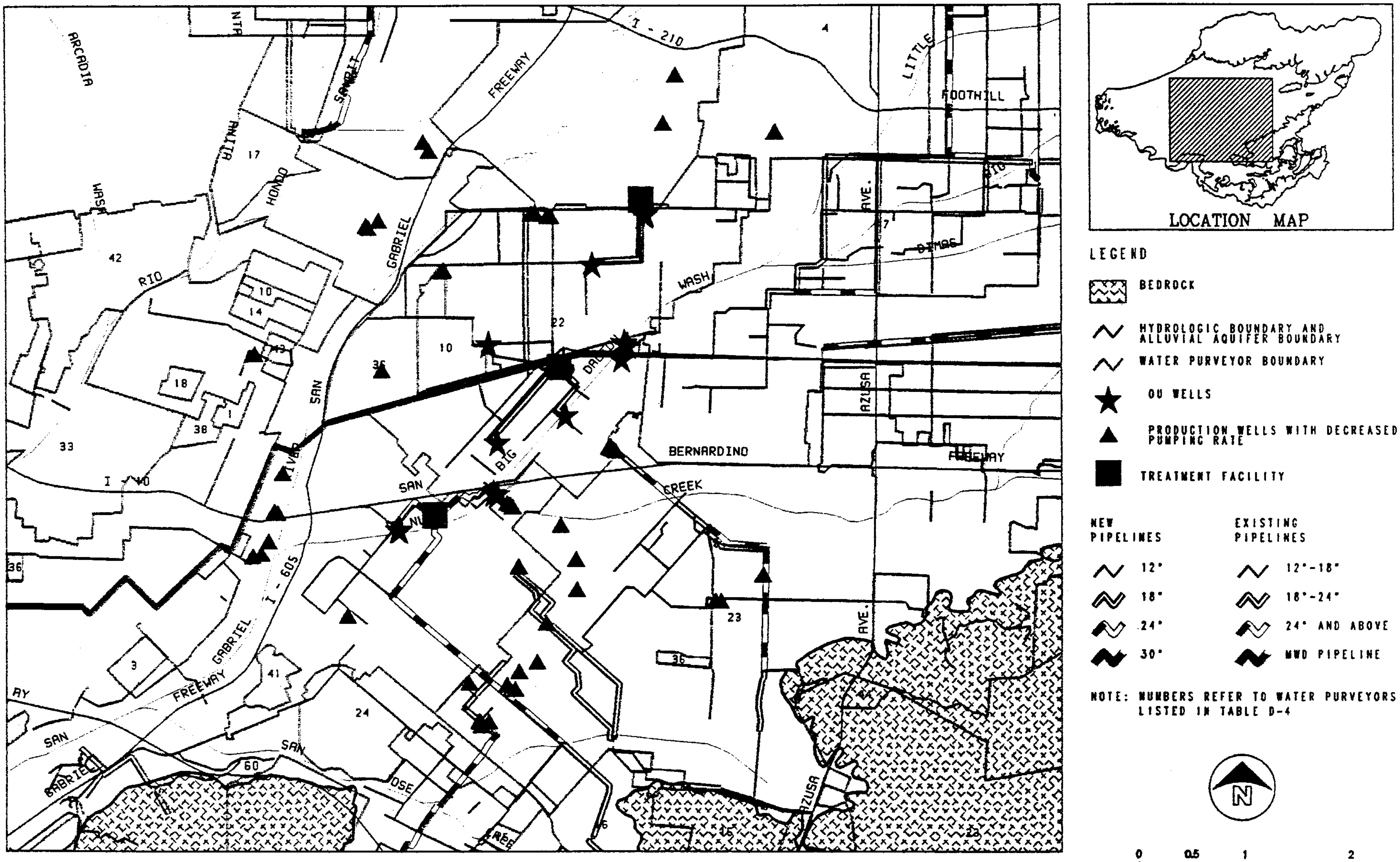

FIGURE D-11

WATER SUPPLY AND DISTRIBUTION

OU5CDGFIJ - FIRST ALTERNATIVE

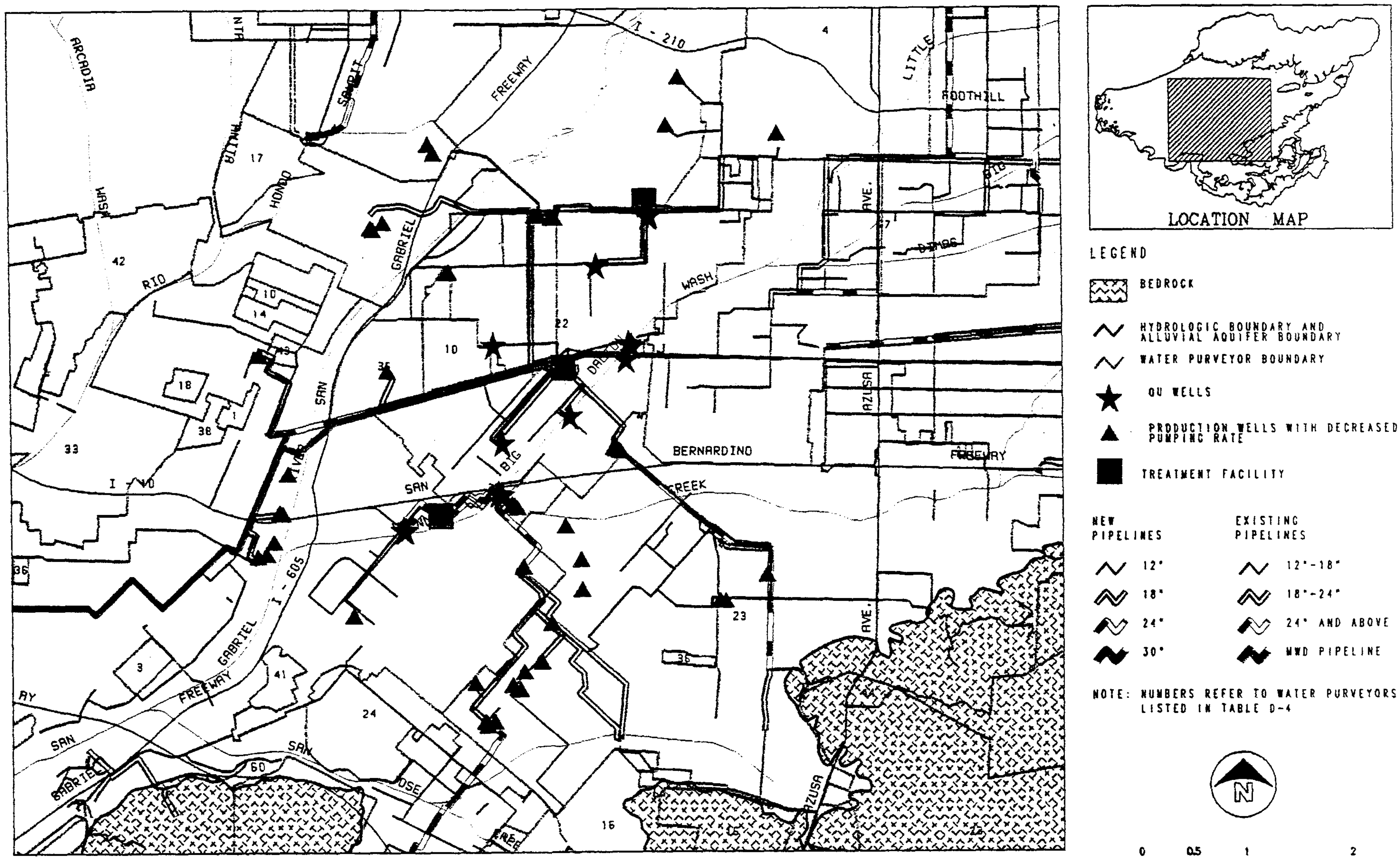

FIGURE D-12

WATER SUPPLY AND DISTRIBUTION

OU5CDGFIJ - SECOND ALTERNATIVE

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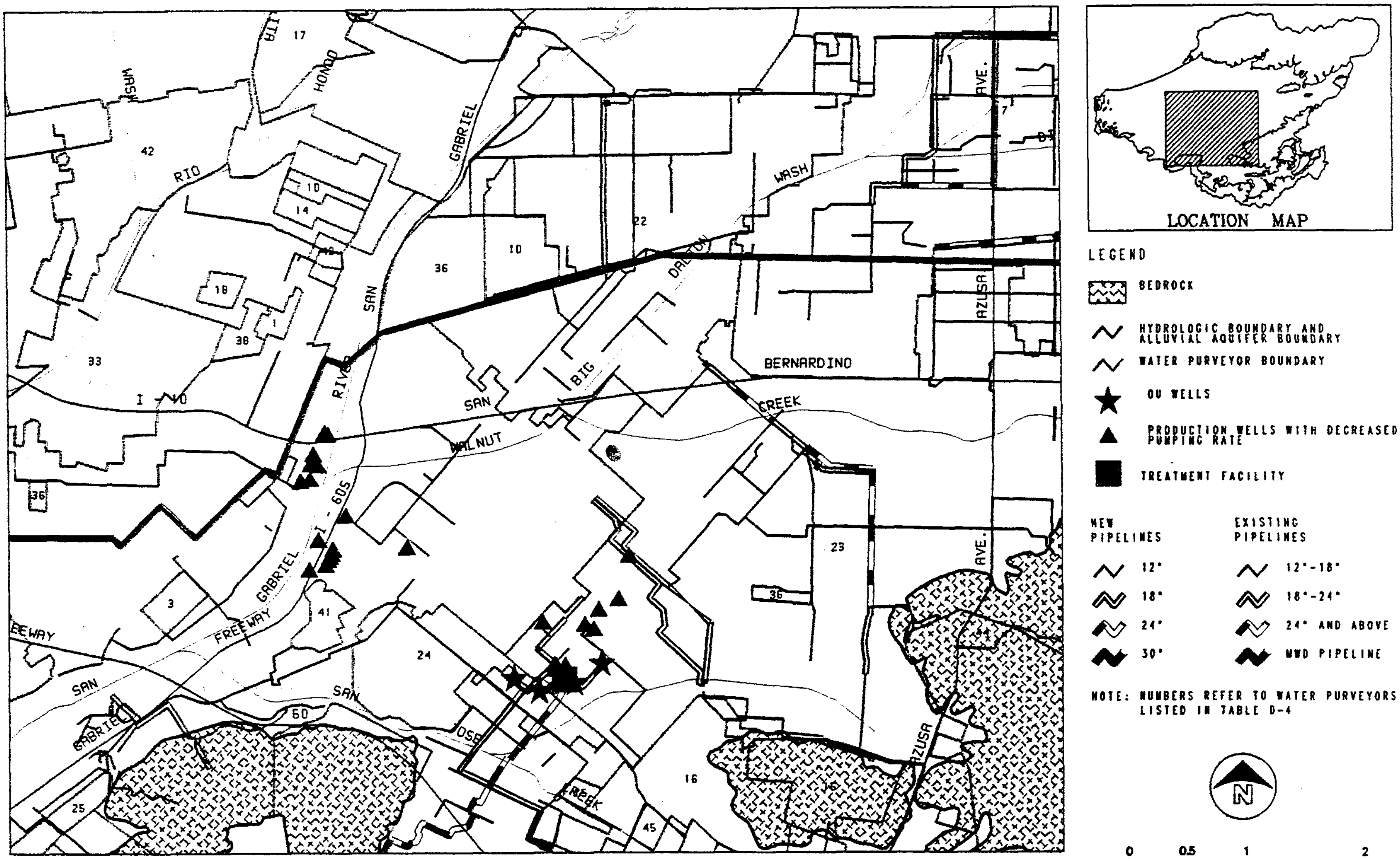

FIGURE D-13

WATER SUPPLY AND DISTRIBUTION

OU5W - FIRST ALTERNATIVE

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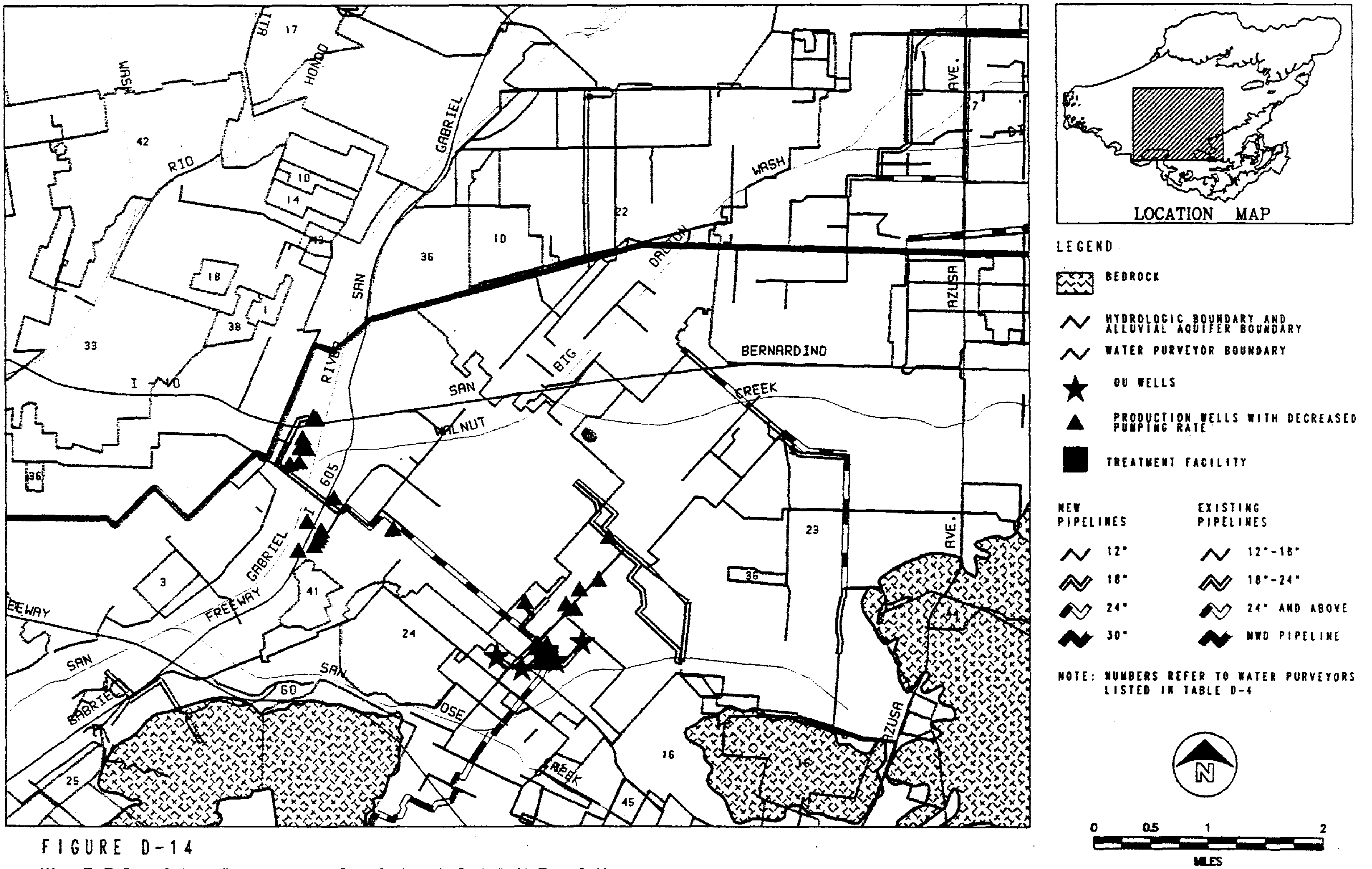

FIGURE D-14

WATER SUPPLY AND DISTRIBUTION

OU5W - SECOND ALTERNATIVE

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Table D-15
OU 5CDGFIJ WELL OWNERSHIP DISTRIBUTION

Purveyor/Owner	Number of Wells	Well Recordation Number
Extraction Wells		
Valley County Water District	5	01900034, 08000060, 01900035, 01900031, 08000039
Polopolus, et. al.	1	01902169
Covina Irrigating Company	3	01900883, 01900882, 01900885
San Gabriel Valley Water	4	71900721, 71903093, 51902858, 51902947
Shut-Down Wells		
Southwest Suburban Water Systems	20	01903067, 08000093, 01901602, 01902119, 08000095, 01901598, 08000069, 01901600, 01902519, 01902763, 01900337, 01901623, 01901596, 08000077, 01902760, 01901618, 01901606, 41901605, 01901612, 01901599
La Puente Valley County Water	3	08000062, 01901460, 01902859
San Gabriel Valley Water	11	71903093, 61900718, 98000094, 98000068, 91901440, 91901435, 18000082, 11900729, 11902946, 18000081, 91901437
Valley County Water District	4	01902356, 01900027, 01900028, 01900032
San Gabriel County Water	1	08000067
Sonoco Products Company	1	01902971
California Domestic Water	6	01903081, 01901181, 08000100, 01903057, 01901183, 01902967
Conrock Company	1	01902920
Valley View Mutual Water Company	3	01900363, 01900364, 01900365
AZ-Two, Inc.	1	11900038
Los Angeles County	1	08000070
Livingston-Graham, Inc.	3	01901493, 01901492, 01903006
Sully-Miller Contracting	2	01900106, 01903062
Miller Brewing Company	1	08000075

Considering the proximity of the four OU extraction wells, one centrally located treatment facility is considered adequate. Delivery of extracted water to the facility, and of treated water to the purveyor's service area is estimated to require about 4.3 miles of pipeline between 12 and 24 inches in diameter. The location of this pipeline is shown in the first alternative layout on Figure D-13.

Table D-16
ESTIMATED PIPELINE LENGTHS AND TREATMENT PLANT CAPACITY REQUIREMENTS
FOR OU 5CDGFIJ

Pipe Line (inches)	Length (feet)	River Crossings	Highway Crossings	Treatment Plant Number	Size (gpm)	VOC Concentration (ppb)	Nitrate Concentration (ppm)
Alternative No. 1							
12	13,800	0	1	1	12,000	100	>45
18	25,600	4	0	2	12,000	100	>45
24	27,400	0	0	3	15,000	100	>45
Alternative No. 2							
12	68,600	2	2	1	12,000	100	>45
18	53,400	2	2	2	12,000	100	>45
24	47,500	2	2	3	15,000	100	>45

Table D-17
OU 5W WELL OWNERSHIP DISTRIBUTION

Purveyor/Owner	Number of Wells	Well Recordation Number
New Extraction Wells	4	5W000001, 5W000002, 5W000003, 5W000004
Shut-Down Wells		
San Gabriel Valley Water	6	98000094, 98000068, 91901440, 91901435, 91901437, 61900718
Southwest Suburban Water Systems	7	01900337, 01901623, 01901596, 08000077, 01902760, 01902519, 01901627
Sonoco Products Company	1	01902971
City of Industry	5	08000097, 01902582, 08000096, 01902581, 08000078
Ward Duck Company	2	01903072, 01902951
Bahnsen & Beckman, Ind.	2	01902949, 01902950
California Domestic Water	7	01903081, 01901181, 08000100, 01903057, 01901183, 01901182, 01902967

For the second distribution alternative, shown in Figure D-14, shut-down wells in this OU can be grouped into two sets for distribution of treated water. Nine of the shut-down wells are in the vicinity of the OU wells. These are served by a few, relatively short 12- and 18-inch-diameter pipelines. The remainder of the downgradient wells are approximately 2.5 to 3 miles from the OU wells. These may be served by a 24-inch pipeline. Approximately 6.6 miles of pipeline are required for the second alternative. Table D-18 lists pipeline length estimates and the size of the treatment facility required for both alternatives.

Table D-18
ESTIMATED PIPELINE LENGTHS AND TREATMENT PLANT CAPACITY REQUIREMENTS
FOR OU 5W

Pipe Line (inches)	Length (feet)	River Crossings	Highway Crossings	Treatment Plant Number	Size (gpm)	VOC Concentration (ppb)	Nitrate Concentration (ppm)
Alternative No. 1							
12	2,400	0	0	1	10,000	50	>45
18	13,900	0	0				
24	6,500	0	0				
Alternative No. 2							
12	10,500	0	0	1	10,000	50	>45
18	11,100	1	2				
24	13,200	0	0				

D.2.8 OPERABLE UNIT 6AB

Although the original primary objective of OU 6AB, as described in Appendix A, was to provide drinking water, the numerical evaluations described in Appendix C illustrated its ability to slow the migration of contamination in the Puente Valley westward toward Whittier Narrows. This OU utilizes five existing wells currently shut down. The OU wells will produce a total of 1,312 ac-ft/qtr if pumped at capacity, with individual production rates ranging from less than 200 gpm to 1,500 gpm. To balance these extraction rates with historical rates of shut-down wells, this evaluation considers a total production rate of approximately 1,000 ac-ft/qtr, as illustrated in Figure C-24.

The OU wells are located within an area in which groundwater contamination exceeds 25 ug/l. Figures D-15 and D-16 show the locations of extraction and shut-down wells, and the two alternate pipeline configurations. Table D-19 lists these wells by owner. Because of the proximity of the OU wells to one another, one treatment facility is considered adequate.

Table D-19
OU 6AB WELL OWNERSHIP DISTRIBUTION

Purveyor/Owner	Number of Wells	Well Recordation Number
Extraction Wells		
Southwest Suburban Water Systems	5	01901617, 31902820, 31902819, 01901625, 01901621
Shut-Down Wells		
San Gabriel Valley Water	4	98000094, 98000068, 91901440, 91901435
Southwest Suburban Water Systems	10	01900337, 01901623, 01901596, 08000077, 01902760, 01902763, 01912519, 01903067, 08000093, 01901602

The first distribution alternative, shown in Figure D-15, includes over 4 miles of pipeline linking the extraction wells with the treatment facility, and delivering treated water to the purveyor's service area. The location of the treatment facility adjacent to the service areas of existing wells minimizes the need for extensive new pipeline. The second alternative, shown in Figure D-16, includes about 6.6 miles of pipeline to treat the extracted water and deliver it to the shut-down wells. The OU wells are located approximately 3 miles from the first set of shut-down wells. The farthest shut-down well is about 4.5 miles away from the potential treatment facility. Most of the pipeline in the second alternative is 24 inches in diameter. Table D-20 lists estimated pipeline lengths and treatment facility size for both alternatives.

Table D-20
ESTIMATED PIPELINE LENGTHS AND TREATMENT PLANT CAPACITY REQUIREMENTS FOR OU 6AB

Pipe Line (inches)	Length (feet)	River Crossings	Highway Crossings	Treatment Plant Number	Size (gpm)	VOC Concentration (ppb)	Nitrate Concentration (ppm)
Alternative No. 1							
12	2,250	0	0	1	3,250	25	>45
18	13,400	0	0				
24	7,000	0	0				
Alternative No. 2							
12	15,300	0	0	1	3,250	25	>45
18	3,400	0	0				
24	16,400	2	0				

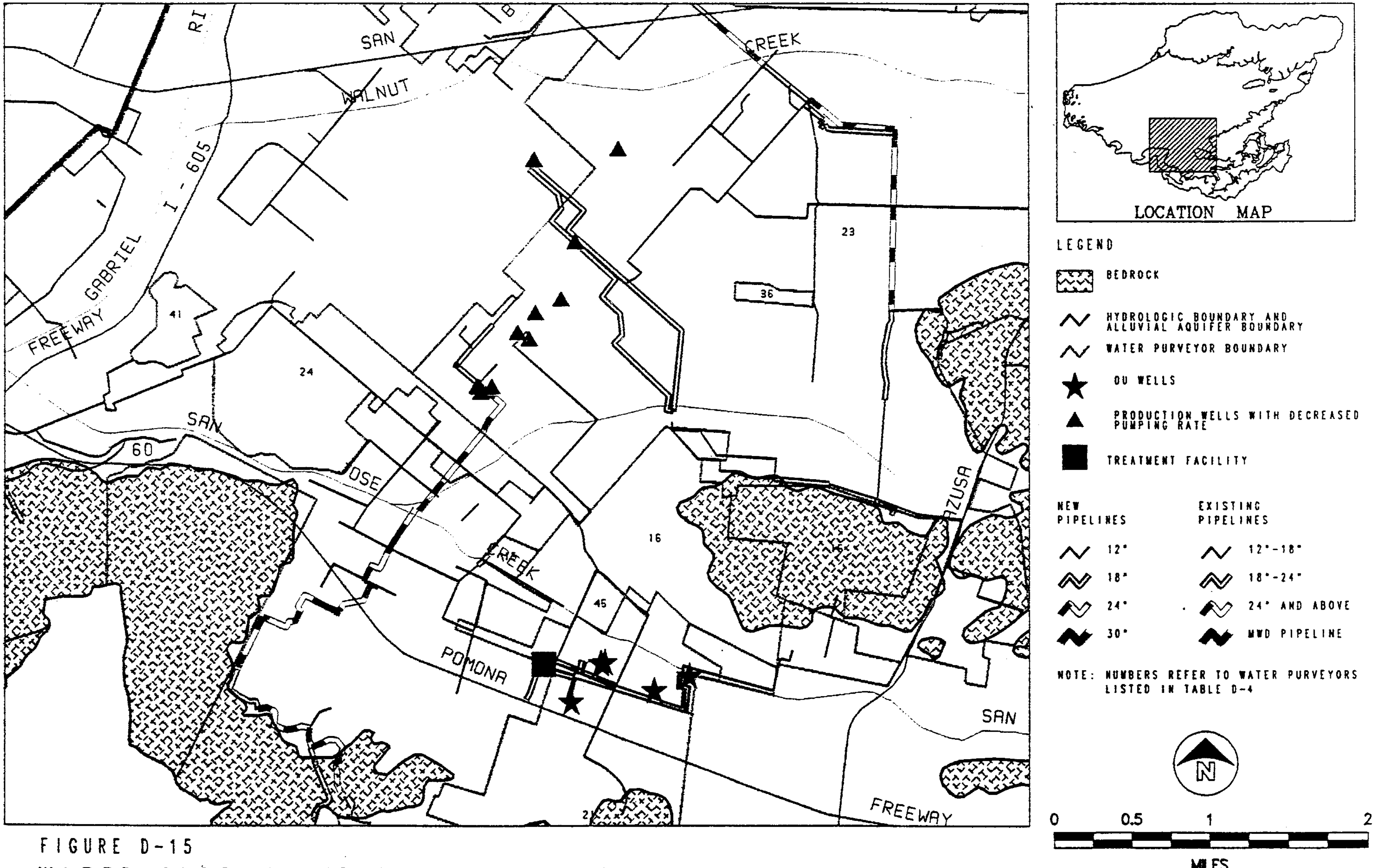

FIGURE D-15

WATER SUPPLY AND DISTRIBUTION

OU6AB - FIRST ALTERNATIVE

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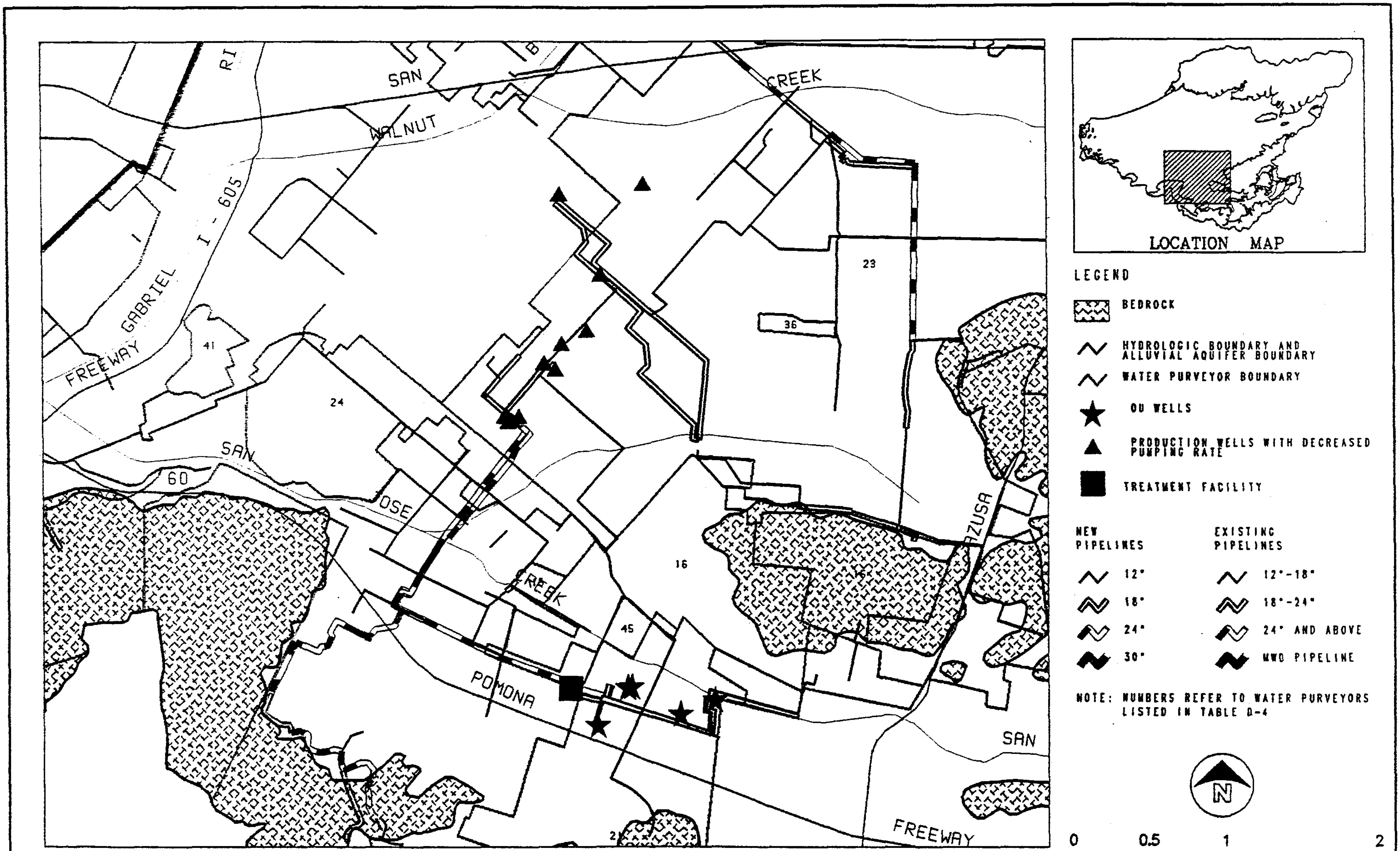

FIGURE D-16

WATER SUPPLY AND DISTRIBUTION

OU6AB - SECOND ALTERNATIVE

Draft Basinwide Technical Plan

San Gabriel Basin

D.3.0 REFERENCES

U.S. Environmental Protection Agency. Draft Whittier Narrows Operable Unit Feasibility Study, San Gabriel Basin, Los Angeles County, California. Prepared for EPA Region IX by CH2M HILL. September 1989.

Appendix E
EVALUATION OF PROBABLE COSTS - REPRESENTATIVE SUBSET OF POTENTIAL OPERABLE UNITS

APPENDIX E

CONTENTS

TABLES

Appendix E
EVALUATION OF PROBABLE COSTS - REPRESENTATIVE SUBSET OF POTENTIAL OPERABLE UNITS

E.1.0 INTRODUCTION

The evaluation of the cost of the representative subset of potential operable units (OU) described in Section 5.1 of Volume One is primarily based on information and assumptions developed in the preceding appendixes. The level of detail of the information available may be described as "prefeasibility-study" level, which implies that in most cases very little design detail is available as an estimate basis. Accordingly, these estimates have been developed using aggregate quantities for the two water distribution system alternatives described in Appendix D, and conceptual-level information for treatment facilities. The simplifying assumptions regarding the configurations of water distribution systems, discussed in Section D.1.0, are reflected in the differing outcomes of the cost estimates for the two alternate distribution scenarios. Because of the low level of detail of the information available, these estimates are inherently conservative.

The estimates prepared in this appendix for the representative subset of potential operable units are Rough Order of Magnitude (ROM) estimates. This type of estimate, which is typically prepared with preliminary or conceptual information, has a range of confidence of -30 percent to +50 percent. Estimates for operable unit feasibility studies (OUFSs) are generally also ROM type estimates, although more information regarding the configuration of the various alternatives is typically available for an OUFS than for the present set of estimates. Thus, additional care should be exercised by the user of the estimates contained herein than for a typical OUFS estimate. In either case, estimated probable costs should be utilized for comparative purposes only.

The pricing of these estimates is for the greater Los Angeles area for mid-1989. No attempt has been made to escalate these costs to a future time period as the specific periods of performance are not readily determinable at this time.

E.2.0 ESTIMATE BASIS AND UNDERLYING ASSUMPTIONS

While the most basic assumptions of these estimates are alluded to above as being inherently conservative, there are specific assumptions applicable to each portion of the OU estimates that should be noted, particularly in regard to the two alternate pumping scenarios. The following paragraphs summarize the assumptions followed in preparing cost estimates for the eight OUs described in Section 5.1.

E.2.1 TREATMENT SYSTEMS

While the discussion of available treatment technologies in Section D.1.3 states that the actual selection of a specific technology for an OU will be made as part of the Feasibility Study, Air Stripping (with vapor-phase carbon-absorption off-gas treatment where applicable[1]) is assumed for costing purposes. For treatment facilities smaller than 3,000 gallons per minute (gpm), the Cost of Remedial Action (CORA) model (EPA, 1988a) is used as the basis for capacity factoring from a 2,000-gpm basis. For larger (multiple trained) treatment facilities, the Preliminary-Level estimate for Alternative 4 (Probable Conditions) of the Draft Whittier Narrows OUFS (EPA, 1989) is utilized as the basis for capacity factoring from its 13,000-gpm basis.

It is also assumed that ion-exchange units will be used for nitrate removal. Cost information has been obtained from the literature regarding ion-exchange units for nitrate removal. Ion-exchange cost estimates have been adjusted by capacity factoring to the requirements of specific OUs. Influent concentrations of 60 parts per million (ppm) were assumed for the purposes of this estimate. The estimate assumes that a sidestream of approximately one-third of the treatment facility flow will be treated and blended to deliver water that satisfies the current state and federal drinking water standard of 45 ppm for nitrates.

E.2.2 DISTRIBUTION PIPELINES AND APPUTERANCES

The estimate quantities for distribution pipelines and their apputerances (shutoff valves, pressure-safety valves, road and river crossings, etc.) have been developed based on information presented for the 16 scenarios (2 alternatives for each OU) described in Appendix D as aggregate values. Unit costs previously developed for use on this project have been applied where applicable. All pipelines within OUs are assumed to be constructed through developed areas. This is a significant departure from previous estimates prepared for the Whittier Narrows and Suburban Water Systems OUFSs (EPA, 1989, and 1988b, respectively), in which a large portion of the pipelines could be reasonably assumed to be constructed through undeveloped areas in the Whittier Narrows Dam Basin. Otherwise, the pipeline design assumptions in Section D.1.5 are applicable.

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[1] The South Coast Air Quality Management District (SCAQMD) requires emissions to remain within 1 pound per day (lb/day) of contaminants (SCAQMD, 1988). To meet this requirement, off-gas treatment is assumed to be required at each of the eight representative operable units, with the exception of OU 1E, where emissions should remain below 1 lb/day without treatment.

E.2.3 EXTRACTION WELLS

Pricing for extraction wells is based on assumptions developed for the Draft Whittier Narrows OUFS (EPA, 1989) and were developed for a 2000-gpm-capacity extraction well as a base case.

E.2.4 SURFACE AND EXTRACTION PUMPAGE

Extraction pumping costs are based on estimated power consumption for the extraction volume described in Appendix A, Table A-1, and a lift of 100 feet above the water table at the extraction well location.

Surface pumping costs have been estimated assuming that pipelines conducting water from OU extraction wells to treatment facilities will be consistent with the Pipeline Design Assumptions in Section D.1.5. These costs largely reflect allowances for frictional losses at the volumes described, at a velocity of approximately 5 feet per second (fps). Pump costs for redistributing treated water to the original well location assume that water will be transferred from the treatment plant outlet at 90 pounds per square inch (psi). It is assumed that for each individual OU there will be no net change in pumping and delivery elevations overall.

E.2.5 DETERMINATION OF REMEDIAL ACTION IMPLEMENTATION COSTS

Total implementation costs for remedial actions for each potential OU are factored using a pricing pattern defined in the REM IV Cost Estimating Guidance used to prepare feasibility estimates. Land acquisition costs are assumed to be based on a cost of $300,000 per acre for rough graded industrial sites with streets, street lights, and all utilities available at the curbline. One one-acre site is assumed to be required for each treatment facility.

E.2.6 REMEDIAL INVESTIGATIONS

The cost estimates of remedial investigations are based on actual experience on the San Gabriel Basin Remedial Investigation/Feasibility Study (RI/FS) project. These estimates include technical labor to evaluate existing data, prepare field sampling and site safety plans, provide field technical oversight and subcontract administration, validate resultant field data, evaluate data, and prepare technical memoranda. Subcontract costs for monitoring well installations and well logging and depth-specific sampling are based upon actual costs experienced in the performing field work for the Whittier Narrows OUFS (EPA, 1989).

E.2.7 FEASIBILITY STUDY COSTS

The expected costs of performing feasibility studies have been developed for hypothetical large and small OUs. The large OU is estimated at 80 percent of the cost and Level of Effort (LOE) of the feasibility study tasks from the July 1989 Estimated-at-Completion values for the Draft Whittier Narrows OUFS (EPA, 1989). The small OU is based on a rough average of the actual costs for the Draft Suburban Water Systems OUFS and the estimated cost of a potential OUFS in the Baldwin Park area (Stage 1 San Gabriel Basin RI/FS Work Plan Revision Request No. 3 [August 1988]), escalated to mid-1989 costs.

E.2.8 OPERATION AND MAINTENANCE COSTS

Operation and Maintenance (O&M) costs have been developed for pipelines, pumps, and both sizes of treatment facilities. The O&M costs for pipelines are factored from their estimated capital cost. The cost of pumping is based on capital costs and anticipated power consumption. The cost of air-stripping units and off-gas treatment systems has been developed using a costing pattern developed for Alternative 4 (Probable Conditions) of the Whittier Narrows OUFS (EPA, 1989). O&M costs for nitrate removal facilities are based on actual operating costs at Metropolitan Water District's (MWD's) 1-million-gallon-per-day (mgd) facility at McFarland, California, escalated from the 1985-1986 period and adjusted for regional cost differences between the San Joaquin Valley and the Los Angeles Metropolitan area.

E.3.0 EVALUATIONS OF PROBABLE COST FOR THE REPRESENTATIVE SUBSET OF POTENTIAL OPERABLE UNITS

Estimated costs for the implementation, operation, and maintenance of the subset of eight representative OUs described in Section 5.1 are presented in the following sections. For each OU, two tables of associated costs are included: one describing the costs associated with each of the two alternate distribution scenarios. As described in Appendix D, the first distribution alternative provides pipelines to convey treated water to either existing pipelines or to the boundaries of affected purveyors. The second alternative includes sufficient pipeline to deliver water to each of the wells at which pumping may be reduced or eliminated. The actual distribution system adopted at a specific OU will be determined during the feasibility-study and design phases of the OU. It is expected that actual costs will be somewhere between those presented below for the two alternatives. The summaries of these costs presented throughout Volume One and in Appendix F assume a median (or arithmetic mean) of the two sets of costs.

E.3.1 OPERABLE UNIT 1E

Estimated costs for implementing OU 1E for the two alternate pumping scenarios described in Appendix D are summarized in Tables E-1 and E-2. It is noteworthy that neither of the two treatment facilities requires off-gas carbon absorption treatment because of the relatively small flows and concentrations anticipated. The total Remedial Action (RA) Capital Cost for the first OU 1E alternative is estimated at $7,501,000, with a total OU Cost, including remedial investigation and feasibility study costs, of $8,133,000 (Table E-1). The total RA Capital Cost for the second OU 1E alternative (Table E-2) is estimated at $9,332,000, with a total OU Cost of $9,964,000. The estimated annual O&M costs of the two alternatives are $188,000 and $211,000, respectively.

E.3.2 OPERABLE UNIT 2J

Cost estimates to implement Operable Unit 2J are presented in Tables E-3 and E-4. The Capital Cost for the first distribution alternative for this OU, which includes three extraction wells, a single treatment facility utilizing air stripping with vapor-phase carbon off-gas treatment, and distribution piping and required pumps, is estimated at $21,419,000 with a Total OU Cost of $22,266,000. The annual O&M cost is estimated at $589,000 for the first alternative.

The increased pipeline requirements of the second distribution alternative bring the total Capital Cost to $24,375,000, with a total cost of implementation estimated at $25,222,200 (Table E-4). The associated annual O&M estimate is $644,000.

E.3.3 OPERABLE UNIT 2BCFK

This OU is characterized by relatively large piping quantities, particularly for the second distribution alternative. Capital and O&M cost estimates for the two distribution scenarios are summarized in Tables E-5 and E-6. Estimated treatment costs incorporate vapor-phase carbon treatment on the air stripper off-gas system. The estimated Capital Cost for the first distribution alternative is $40,456,000 while the Total OU Cost is estimated at $41,420,600.

Costs estimated for the second distribution alternative are presented in Table E-6. As shown, the estimated total Capital Cost is $64,444,000. Estimated remedial investigation and feasibility study costs bring the total to $65,408,600. The estimated annual O&M costs for the two alternatives are $1,560,000, and $1,926,000, respectively.

Table E-1
COST ESTIMATES FOR OU 1E - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$203,900
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000
TOTAL GENERAL				$575,100
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	13950	LF	$49.00	$683,600
18" Dia CL52 DI Pipe	8200	LF	$65.20	$534,600
River Crossings				
For 12" Dia CL 52 DI Pipe	2	EA	$36,000	$72,000
For 18" Dia CL 52 DI Pipe	1	EA	$46,600	$46,600
Shutoff Valves				
For 12" Pipe	9	EA	$3,000	$27,900
For 18" Pipe	5	EA	$6,600	$36,100
Pressure Relief/Blowoff Valve Sta.	1	LS		$60,900
Easement Cost	1	LS		$127,100
Pumping				
Surface Xfer Pumps	570	HP		$951,900
New Well Pumps	0	HP	$1,350	$0
Power Tap In	1	LS		$142,800
TOTAL PIPING/PUMPING				$2,683,500
TREATMENT				
Air Stripping Facilities(1500gpm)	2	EA	$172,000	$344,000
TOTAL TREATMENT				$344,000

Table E-1 (Continued)
COST ESTIMATES FOR OU 1E - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
CONSTRUCTION SUBTOTAL				$3,602,600
Bid Contingencies @ 15%				$540,400
Scope Contingencies @ 25%				$900,700

CONSTRUCTION TOTAL				$5,043,700
Services During Construction @ 10%				$504,400
Land Acquisition	2	EA	$300,000	$600,000

TOTAL RA IMPLEMENTATION COST				$6,148,100
Engineering, Legal & Admin Cost @ 22%				$1,352,600

TOTAL CAPITAL COST				$7,501,000
				============
REMEDIAL INVESTIGATION:				
Well Logging & Depth Sampling	2	EA	$44,800	$89,600

TOTAL REMEDIAL INVESTIGATION:				$89,600
FEASIBILITY STUDY:				
Small FS Study	1	LS	$542,400	$542,400

TOTAL RI/FS COST:				$632,000
				============
TOTAL OU COST:				$8,133,000
ANNUAL OPERATIONS & MAINTENANCE COST				
Pipeline & Pump	1	LS	$73,800	$73,800
Treatment Facilities	1	LS	$114,000	$114,000

TOTAL ANNUAL O & M COST:				$188,000
				============

Notes:

Unit Codes
- LS = lump sum
- MO = month
- EA = each
- LF = linear feet
- HP = horsepower

Abbreviations
- Mob = mobilization
- " = inches
- Xfer= transfer
- FS = feasibility study
- RI = remedial investigation
- CL = class
- DI = ductile iron

Table E-2
COST ESTIMATES FOR OU 1E - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$259,100
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000
TOTAL GENERAL				$630,300
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	21000	LF	$49.00	$1,029,000
18" Dia CL52 DI Pipe	15000	LF	$65.20	$978,000
River Crossings				
For 12" Dia CL 52 DI Pipe	3	EA	$36,000	$108,000
For 18" Dia CL 52 DI Pipe	1	EA	$46,600	$46,600
Shutoff Valves				
For 12" Pipe	14	EA	$3,000	$42,000
For 18" Pipe	10	EA	$6,600	$66,000
Pressure Relief/Blowoff Valve Sta.	1	LS		$100,400
Easement Cost	1	LS		$206,600
Pumping				
Surface Xfer Pumps	554	HP		$892,700
Power Tap In	1	LS		$133,900
TOTAL PIPING/PUMPING				$3,603,200
TREATMENT				
Air Stripping Facilities(1500gpm)	2	EA	$172,000	$344,000
TOTAL TREATMENT				$344,000

Table E-2 (Continued)
COST ESTIMATES FOR OU 1E - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
CONSTRUCTION SUBTOTAL				$4,577,500
Bid Contingencies @ 15%				$686,600
Scope Contingencies @ 25%				$1,144,400

CONSTRUCTION TOTAL				$6,408,500
Services During Construction @ 10%				$640,900
Land Acquisition	2	EA	$300,000	$600,000

TOTAL RA IMPLEMENTATION COST				$7,649,400
Engineering, Legal & Admin Cost @ 22%				$1,682,900

TOTAL CAPITAL COST				$9,332,000
				============
REMEDIAL INVESTIGATION:				
Well Logging & Depth Sampling	2	EA	$44,800	$89,600

TOTAL REMEDIAL INVESTIGATION:				$89,600
FEASIBILITY STUDY:				
Small FS Study	1	LS	$542,400	$542,400

TOTAL RI/FS COST:				$632,000
				============
TOTAL OU COST:				$9,964,000
ANNUAL OPERATIONS & MAINTENANCE COST				
Pipeline & Pump	1	LS	$96,500	$96,500
Treatment Facilities	1	LS	$114,000	$114,000

TOTAL ANNUAL O & M COST:				$211,000
				============

Notes:

Unit Codes	Abbreviations
LS = lump sum	Mob = mobilization
MO = month	" = inches
EA = each	Xfer= transfer
LF = linear feet	FS = feasibility study
HP = horsepower	RI = remedial investigation
	CL = class
	DI = ductile iron

Table E-3
COST ESTIMATES FOR OU 2J - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$634,300
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000
TOTAL GENERAL				$1,005,500
EXTRACTION WELLS:				
New Well Installations	3	EA	$259,000	$777,000
Electrical (Allowance)	1	LS		$38,900
TOTAL WELLS				$815,900
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	3900	LF	$49.00	$191,100
18" Dia CL52 DI Pipe	12400	LF	$65.20	$808,500
24" Dia CCP Pipe	2900	LF	$93.20	$270,300
30" Dia CCP Pipe	14300	LF	$121.20	$1,733,200
River Crossings				
For 12" Dia CL 52 DI Pipe	1	EA	$36,000	$36,000
For 24" Dia CCP Pipe	2	EA	$60,100	$120,200
Highway Crossings				
Bore & Jack for 30" Dia CCP Pipe	2	EA	$171,600	$343,200
Shutoff Valves				
For 12" Pipe	3	EA	$3,000	$7,800
For 18" Pipe	8	EA	$6,600	$54,600
For 24" Pipe	2	EA	$10,100	$19,500
For 30" Pipe	10	EA	$14,800	$141,100
Pressure Relief/Blowoff Valve Sta.	1	LS		$150,200
Easement Cost	1	LS		$192,300
Pumping				
Surface Xfer Pumpage	1540	HP		$2,382,500
New Well Pumps	649	HP	$2,025	$1,314,900
Power Tap In	1	LS		$554,600
TOTAL PIPING/PUMPING				$8,320,000

Table E-3 (Continued)
COST ESTIMATES FOR OU 2J - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Treatment/Process				
VOC Removal	1	LS	$1,064,000	$1,064,000
TOTAL TREATMENT				$1,064,000
CONSTRUCTION SUBTOTAL				$11,205,400
Bid Contingencies @ 15%				$1,680,800
Scope Contingencies @ 25%				$2,801,400
CONSTRUCTION TOTAL				$15,687,600
Services During Construction @ 10%				$1,568,800
Land Acquisition	1	LS		$300,000
TOTAL IMPLEMENTATION COST				$17,556,400
Engineering, Legal & Admin Cost @ 22%				$3,862,400
TOTAL CAPITAL COST				$21,419,000
REMEDIAL INVESTIGATION:				
Well Logging & Depth Sampling	1	EA	$44,800	$44,800
Monitoring Well Install & Sample	1	EA	$259,800	$259,800
TOTAL REMEDIAL INVESTIGATION:				$304,600
FEASIBILITY STUDY:				
Small FS Study	1	LS	$542,400	$542,400
TOTAL RI/FS COST:				$847,000
TOTAL OU COST:				$22,266,000
ANNUAL OPERATIONS & MAINTENANCE COST				
New Wells	1	LS	$62,100	$62,100
Pipeline & Pump	1	LS	$204,500	$204,500
Treatment Facilities	1	LS	$322,000	$322,000
TOTAL ANNUAL O & M COST:				$589,000

Notes: Unit Codes
- LS = lump sum
- MO = month
- EA = each
- LF = linear feet
- HP = horsepower

Abbreviations
- Mob = mobilization
- " = inches
- Xfer= transfer
- FS = feasibility study
- RI = remedial investigation
- CL = class
- DI = ductile iron

Table E-4
COST ESTIMATES FOR OU 2J - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$723,300
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000
TOTAL GENERAL				$1,094,500
EXTRACTION WELLS:				
New Well Installations	3	EA	$259,000	$777,000
Electrical (Allowance)	1	LS		$38,900
TOTAL WELLS				$815,900
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	29000	LF	$49.00	$1,421,000
18" Dia CL52 DI Pipe	13000	LF	$65.20	$847,600
24" Dia CCP Pipe	11000	LF	$93.20	$1,025,200
River Crossings				
For 12" Dia CL 52 DI Pipe	2	EA	$36,000	$72,000
For 24" Dia CCP Pipe	2	EA	$60,100	$120,200
Highway Crossings				
Bore & Jack for 24" Dia CCP Pipe	1	EA	$171,600	$171,600
Shutoff Valves				
For 12" Pipe	19	EA	$3,000	$58,000
For 18" Pipe	9	EA	$6,600	$57,200
For 24" Pipe	7	EA	$10,100	$74,100
Pressure Relief/Blowoff Valve Sta.	1	LS		$164,700
Easement Cost	1	LS		$304,200
Pumping				
Surface Xfer Pumpage	2400	HP		$3,458,000
New Well Pumps	649	HP	$2,025	$1,314,900
Power Tap In	1	LS		$715,900
TOTAL PIPING/PUMPING				$9,804,600

Table E-4 (Continued)
COST ESTIMATES FOR OU 2J - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Treatment/Process				
VOC Removal	1	LS	$1,064,000	$1,064,000
TOTAL TREATMENT				$1,064,000
CONSTRUCTION SUBTOTAL				$12,779,000
Bid Contingencies @ 15%				$1,916,900
Scope Contingencies @ 25%				$3,194,800
CONSTRUCTION TOTAL				$17,890,700
Services During Construction @ 10%				$1,789,100
Land Acquisition	1	LS		$300,000
TOTAL IMPLEMENTATION COST				$19,979,800
Engineering, Legal & Admin Cost @ 22%				$4,395,600
TOTAL CAPITAL COST				$24,375,000
REMEDIAL INVESTIGATION:				
Well Logging & Depth Sampling	1	EA	$44,800	$44,800
Monitoring Well Install & Sample	1	EA	$259,800	$259,800
TOTAL REMEDIAL INVESTIGATION:				$304,600
FEASIBILITY STUDY:				
Small FS Study	1	LS	$542,400	$542,400
TOTAL RI/FS COST:				$847,000
TOTAL OU COST:				$25,222,000
ANNUAL OPERATIONS & MAINTENANCE COST				
New Wells	1	LS	$62,100	$62,100
Pipeline & Pump	1	LS	$260,000	$260,000
Treatment Facilities	1	LS	$322,000	$322,000
TOTAL ANNUAL O & M COST:				$644,000

Note: See Table E-3 for explanation of units and abbreviations.

Table E-5
COST ESTIMATES FOR OU 2BCFK - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$1,196,800
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000

TOTAL GENERAL				$1,568,000
				============
EXTRACTION WELLS:				
New Well Installations	1	EA	$259,000	$259,000
Electrical (Allowance)	1	LS		$13,000

TOTAL WELLS				$272,000
				============
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	28600	LF	$49.00	$1,401,400
18" Dia CL52 DI Pipe	23000	LF	$65.20	$1,499,600
24" Dia CCP Pipe	21850	LF	$93.20	$2,036,400
River Crossings				
For 12" Dia CL 52 DI Pipe	1	EA	$36,000	$36,000
For 18" Dia CL 52 DI Pipe	2	EA	$46,600	$93,200
For 24" Dia CCP Pipe	1	EA	$60,100	$60,100
Highway Crossings				
Bore & Jack for 12" Dia DI Pipe	1	EA	$158,600	$158,600
Shutoff Valves				
For 12" Pipe	19	EA	$3,000	$57,200
For 18" Pipe	15	EA	$6,600	$101,200
For 24" Pipe	15	EA	$10,100	$147,100
Pressure Relief/Blowoff Valve Sta.	1	LS		$246,900
Easement Cost	1	LS		$421,500
Pumping				
Surface Xfer Pumps	6706	HP		$9,052,900
New Well Pumps	216	HP	$2,025	$438,300
Power Tap In	1	LS		$1,357,900

TOTAL PIPING/PUMPING				$17,108,300
				============

Table E-5 (Continued)
COST ESTIMATES FOR OU 2BCFK - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Plant No. 1 (23,750gpm)				
VOC Removal	1	LS	$1,866,000	$1,866,000
Plant No. 2 (4,850gpm)				
VOC Removal	1	LS	$329,000	$329,000
TOTAL TREATMENT				$2,195,000
CONSTRUCTION SUBTOTAL				$21,143,300
Bid Contingencies @ 15%				$3,171,500
Scope Contingencies @ 25%				$5,285,800
CONSTRUCTION TOTAL				$29,600,600
Services During Construction @ 10%				$2,960,100
Land Acquisition	2	EA	$300,000	$600,000
TOTAL IMPLEMENTATION COST				$33,160,700
Engineering, Legal & Admin Cost @ 22%				$7,295,400
TOTAL CAPITAL COST				$40,456,000
REMEDIAL INVESTIGATION:				
Monit. Well Install'n & Sampling	1	EA	$200,600	$200,600
Production Well Sampling	1	LS	$40,000	$40,000
TOTAL REMEDIAL INVESTIGATION:				$240,600
FEASIBILITY STUDY:				
FS Study - Large	1	LS	$724,000	$724,000
TOTAL RI/FS COST:				$964,600
TOTAL OU COST:				$41,420,600
ANNUAL OPERATIONS & MAINTENANCE COST				
New Wells	1	LS	$20,700	$20,700
Pipeline & Pump	1	LS	$634,800	$634,800
Treatment Facilities	1	LS	$904,300	$904,300
TOTAL ANNUAL O & M COST:				$1,560,000

Note: See Table E-3 for explanation of units and abbreviations.

Table E-6
COST ESTIMATES FOR OU 2BCFK - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$1,919,500
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000
TOTAL GENERAL				$2,290,700
EXTRACTION WELLS:				
New Well Installations	1	EA	$259,000	$259,000
Electrical (Allowance)	1	LS		$13,000
TOTAL WELLS				$272,000
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	57000	LF	$49.00	$2,793,000
18" Dia CL52 DI Pipe	42000	LF	$65.20	$2,738,400
24" Dia CCP Pipe	27000	LF	$93.20	$2,516,400
River Crossings				
For 12" Dia CL 52 DI Pipe	4	EA	$36,000	$144,000
For 18" Dia CL 52 DI Pipe	4	EA	$46,600	$186,400
For 24" Dia CCP Pipe	4	EA	$60,100	$240,400
Highway Crossings				
Bore & Jack for 18" Dia DI Pipe	1	EA	$158,600	$158,600
Shutoff Valves				
For 12" Pipe	38	EA	$3,000	$114,000
For 18" Pipe	28	EA	$6,600	$184,800
For 24" Pipe	18	EA	$10,100	$181,800
Pressure Relief/Blowoff Valve Sta.	1	LS		$402,400
Easement Cost	1	LS		$723,100
Pumping				
Surface Xfer Pumps	9618	HP		$15,940,700
New Well Pumps	216	HP	$2,025	$438,300
Power Tap In	1	LS		$2,391,100
TOTAL PIPING/PUMPING				$29,153,400

Table E-6 (Continued)
COST ESTIMATES FOR OU 2BCFK - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Plant No. 1 (23,750gpm)				
VOC Removal	1	LS	$1,866,000	$1,866,000
Plant No. 2 (4,850gpm)				
VOC Removal	1	LS	$329,000	$329,000
TOTAL TREATMENT				$2,195,000
CONSTRUCTION SUBTOTAL				$33,911,100
Bid Contingencies @ 15%				$5,086,700
Scope Contingencies @ 25%				$8,477,800
CONSTRUCTION TOTAL				$47,475,600
Services During Construction @ 10%				$4,747,600
Land Acquisition	2	EA	$300,000	$600,000
TOTAL IMPLEMENTATION COST				$52,823,200
Engineering, Legal & Admin Cost @ 22%				$11,621,100
TOTAL CAPITAL COST				$64,444,000
REMEDIAL INVESTIGATION:				
Monit. Well Install'n & Sampling	1	EA	$200,600	$200,600
Production Well Sampling	1	LS	$40,000	$40,000
TOTAL REMEDIAL INVESTIGATION:				$240,600
FEASIBILITY STUDY:				
FS Study - Large	1	LS	$724,000	$724,000
TOTAL RI/FS COST:				$964,600
TOTAL OU COST:				$65,408,600
ANNUAL OPERATIONS & MAINTENANCE COST				
New Wells	1	LS	$20,700	$20,700
Pipeline & Pump	1	LS	$1,000,800	$1,000,800
Treatment Facilities	1	LS	$904,300	$904,300
TOTAL ANNUAL O & M COST:				$1,926,000

Note: See Table E-3 for explanation of units and abbreviations.

E.3.4 OPERABLE UNIT 4K

The estimated costs to implement both distribution alternatives for Operable Unit 4K are presented in Tables E-7 and E-8. The estimated costs for this OU include three extraction wells, two treatment facilities utilizing air stripping with vapor-phase carbon off-gas treatment for volatile organic compound (VOC) removal with ion-exchange units for nitrate removal, and piping and associated pumps. Total Capital Cost of implementation is estimated at $15,563,000 with a total OU Cost of $16,105,400.

In contrast, as shown in Table E-8, distributing treated water directly to the affected wells increases the total Capital Cost to $21,274,000, and the total OU Cost to $21,816,400. Annual O&M costs for the two distribution alternatives are estimated at $495,000 and $558,000, respectively.

E.3.5 OPERABLE UNIT 5TUV

The estimated costs of implementing OU 5TUV with the first piping alternative are presented in Table E-9. The total Capital Cost for this operable unit, which includes three extraction wells, a single treatment facility utilizing air stripping with vapor-phase carbon off-gas treatment for VOC removal with ion-exchange units for nitrate removal, and piping and associated pumping, is estimated at $29,074,000 with a Total OU Cost of $29,798,000, assuming the first distribution alternative will be sufficient. The annual O&M cost of 5TUV is estimated at $881,000 using the first distribution alternative.

These cost estimates are adjusted for the second distribution alternative in Table E-10. Using the second alternative, the total Capital Cost is estimated at $35,280,000. Including remedial investigation and a feasibility study, estimated implementation costs total $36,004,000. O&M costs for this operable unit with the second distribution scenario are estimated to total $985,000.

E.3.6 OPERABLE UNIT 5CDGFIJ

Operable Unit 5CDGFIJ includes three treatment facilities for removal of both VOCs and nitrates, and substantial distribution piping and associated pumping for both distribution alternatives. The total Capital Cost for the first alternative (Table E-11) is estimated at $51,435,000 with a Total OU Cost of $52,937,400. The annual O&M costs estimated for this alternative are $3,591,000. The costs estimated for the second distribution alternative for OU 5CDGFIJ are listed in Table E-12. Pumping treated water to the wells at which pumping is reduced or eliminated results in a total estimated Capital Cost of $89,674,000. The total cost of implementing the second alternative is estimated at $91,176,400, with an annual estimated O&M cost of $4,283,000.

Table E-7
COST ESTIMATES FOR OU 4K - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$446,800
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000

TOTAL GENERAL				$818,000
				============
EXTRACTION WELLS:				
New Well Installations	3	EA	$259,000	$777,000
Electrical (Allowance)	1	LS		$38,900

TOTAL WELLS				$815,900
				============
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	9600	LF	$49.00	$470,400
18" Dia CL52 DI Pipe	21600	LF	$65.20	$1,408,300
River Crossings				
For 12" Dia CL 52 DI Pipe	1	EA	$36,000	$36,000
Highway Crossings				
Bore & Jack for 12" Dia DI Pipe	1	EA	$158,600	$158,600
Shutoff Valves				
For 12" Pipe	6	EA	$3,000	$19,200
For 18" Pipe	14	EA	$6,600	$95,000
Pressure Relief/Blowoff Valve Sta.	1	LS		$93,900
Easement Cost	1	LS		$179,100
Pumping				
Surface Transfer Pumps	543	HP		$1,366,100
New Well Pumps	325	HP	$2,025	$657,500
Power Tap In	1	LS		$303,500

TOTAL PIPING/PUMPING				$4,787,600
				============

Table E-7 (Continued)
COST ESTIMATES FOR OU 4K - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Treatment/Process				
VOC Removal	2	LS	$247,300	$494,600
Nitrate Removal	2	LS	$488,900	$977,800
TOTAL TREATMENT				$1,472,400
CONSTRUCTION SUBTOTAL				$7,893,900
Bid Contingencies @ 15%				$1,184,100
Scope Contingencies @ 25%				$1,973,500
CONSTRUCTION TOTAL				$11,051,500
Services During Construction @ 10%				$1,105,200
Land Acquisition	2	EA	$300,000	$600,000
TOTAL IMPLEMENTATION COST				$12,756,700
Engineering, Legal & Admin Cost @ 22%				$2,806,500
TOTAL CAPITAL COST				$15,563,000
FEASIBILITY STUDY:				
Small FS Study	1	LS	$542,400	$542,400
TOTAL RI/FS COST:				$542,400
TOTAL OU COST:				$16,105,400
ANNUAL OPERATIONS & MAINTENANCE COST				
New Wells	1	LS	$31,000	$31,000
Pipeline & Pump	1	LS	$102,800	$102,800
Treatment Facilities	1	LS	$361,300	$361,300
TOTAL ANNUAL O & M COST:				$495,000

Notes:

Unit Codes
- LS = lump sum
- MO = month
- EA = each
- LF = linear feet
- HP = horsepower

Abbreviations
- Mob = mobilization
- " = inches
- Xfer= transfer
- FS = feasibility study
- RI = remedial investigation
- CL = class
- DI = ductile iron

Table E-8
COST ESTIMATES FOR OU 4K - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$618,900
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000

TOTAL GENERAL				$990,100
				============
EXTRACTION WELLS:				
New Well Installations	3	EA	$259,000	$777,000
Electrical (Allowance)	1	LS		$38,900

TOTAL WELLS				$815,900
				============
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	21000	LF	$49.00	$1,029,000
18" Dia CL52 DI Pipe	32000	LF	$65.20	$2,086,400
River Crossings				
For 12" Dia CL 52 DI Pipe	2	EA	$36,000	$72,000
For 18" Dia CL 52 DI Pipe	1	EA	$46,600	$46,600
Highway Crossings				
Bore & Jack for 12" Dia DI Pipe	1	EA	$158,600	$158,600
Bore & Jack for 18" Dia DI Pipe	4	EA	$158,600	$634,400
Shutoff Valves				
For 12" Pipe	14	EA	$3,000	$42,000
For 18" Pipe	21	EA	$6,600	$140,800
Pressure Relief/Blowoff Valve Sta.	1	LS		$155,800
Easement Cost	1	LS		$304,200
Pumping				
Surface Transfer Pumps	684	HP		$1,938,600
New Well Pumps	325	HP	$2,025	$657,500
Power Tap In	1	LS		$389,400

TOTAL PIPING/PUMPING				$7,655,300
				============

Table E-8 (Continued)
COST ESTIMATES FOR OU 4K - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Treatment/Process				
VOC Removal	2	LS	$247,300	$494,600
Nitrate Removal	2	LS	$488,900	$977,800
TOTAL TREATMENT				$1,472,400
CONSTRUCTION SUBTOTAL				$10,933,700
Bid Contingencies @ 15%				$1,640,100
Scope Contingencies @ 25%				$2,733,400
CONSTRUCTION TOTAL				$15,307,200
Services During Construction @ 10%				$1,530,700
Land Acquisition	2	EA	$300,000	$600,000
TOTAL IMPLEMENTATION COST				$17,437,900
Engineering, Legal & Admin Cost @ 22%				$3,836,300
TOTAL CAPITAL COST				$21,274,000
FEASIBILITY STUDY:				
Small FS Study	1	LS	$542,400	$542,400
TOTAL RI/FS COST:				$542,400
TOTAL OU COST:				$21,816,400
ANNUAL OPERATIONS & MAINTENANCE COST				
New Wells	1	LS	$31,000	$31,000
Pipeline & Pump	1	LS	$165,700	$165,700
Treatment Facilities	1	LS	$361,300	$361,300
TOTAL ANNUAL O & M COST:				$558,000

Notes: Unit Codes
- LS = lump sum
- MO = month
- EA = each
- LF = linear feet
- HP = horsepower

Abbreviations
- Mob = mobilization
- " = inches
- Xfer= transfer
- FS = feasibility study
- RI = remedial investigation
- CL = class
- DI = ductile iron

Table E-9
COST ESTIMATES FOR OU 5TUV - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$864,900
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000
TOTAL GENERAL				$1,236,100
EXTRACTION WELLS:				
New Well Installations	3	EA	$259,000	$777,000
Electrical (Allowance)	1	LS		$38,900
TOTAL WELLS				$815,900
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	4900	LF	$49.00	$240,100
18" Dia CL52 DI Pipe	31700	LF	$65.20	$2,066,800
24" Dia CCP Pipe	26100	LF	$93.20	$2,432,500
River Crossings				
For 12" Dia CCP Pipe	1	EA	$36,000	$36,000
Highway Crossings				
Bore & Jack for 24" Dia CCP Pipe	1	EA	$171,600	$171,600
Shutoff Valves				
For 12" Pipe	3	EA	$3,000	$9,800
For 18" Pipe	21	EA	$6,600	$139,500
For 24" Pipe	17	EA	$10,100	$175,700
Pressure Relief/Blowoff Valve Sta.	1	LS		$237,000
Easement Cost	1	LS		$359,800
Pumping				
Surface Transfer Pumpage	1964	HP		$2,651,300
New Well Pumps	947	HP	$2,025	$1,917,600
Power Tap In	1	LS		$685,300
TOTAL PIPING/PUMPING				$11,123,000

Table E-9 (Continued)
COST ESTIMATES FOR OU 5TUV - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Treatment/Process				
VOC Removal	1	LS	$1,064,000	$1,064,000
Nitrate Removal	1	LS	$1,041,100	$1,041,100
TOTAL TREATMENT				$2,105,100
CONSTRUCTION SUBTOTAL				$15,280,100
Bid Contingencies @ 15%				$2,292,000
Scope Contingencies @ 25%				$3,820,000
CONSTRUCTION TOTAL				$21,392,100
Services During Construction @ 10%				$2,139,200
Land Acquisition	1	LS		$300,000
TOTAL IMPLEMENTATION COST				$23,831,300
Engineering, Legal & Admin Cost @ 22%				$5,242,900
TOTAL CAPITAL COST				$29,074,000
FEASIBILITY STUDY:				
FS Study - Large	1	LS	$724,000	$724,000
TOTAL RI/FS COST:				$724,000
TOTAL OU COST:				$29,798,000
ANNUAL OPERATIONS & MAINTENANCE COST				
New Wells	1	LS	$90,500	$90,500
Pipeline & Pump	1	LS	$228,100	$228,100
Treatment Facilities	1	LS	$562,200	$562,200
TOTAL ANNUAL O & M COST:				$881,000

Notes:

Unit Codes	Abbreviations
LS = lump sum	Mob = mobilization
MO = month	" = inches
EA = each	Xfer= transfer
LF = linear feet	FS = feasibility study
HP = horsepower	RI = remedial investigation
	CL = class
	DI = ductile iron

Table E-10
COST ESTIMATES FOR OU 5TUV - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$1,051,900
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000

TOTAL GENERAL				$1,423,100
				============
EXTRACTION WELLS:				
New Well Installations	3	EA	$259,000	$777,000
Electrical (Allowance)	1	LS		$38,900

TOTAL WELLS				$815,900
				============
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	7400	LF	$49.00	$362,600
18" Dia CL52 DI Pipe	19800	LF	$65.20	$1,291,000
24" Dia CCP Pipe	48800	LF	$93.20	$4,548,200
River Crossings				
For 24" Dia CCP Pipe	2	EA	$60,100	$120,200
Highway Crossings				
Bore & Jack for 12" Dia DI Pipe	1	EA	$158,600	$158,600
Bore & Jack for 18" Dia DI Pipe	1	EA	$158,600	$158,600
Bore & Jack for 24" Dia CCP Pipe	2	EA	$171,600	$343,200
Shutoff Valves				
For 12" Pipe	5	EA	$3,000	$14,800
For 18" Pipe	13	EA	$6,600	$87,100
For 24" Pipe	33	EA	$10,100	$328,600
Pressure Relief/Blowoff Valve Sta.	1	LS		$310,100
Easement Cost	1	LS		$436,200
Pumping				
Surface Transfer Pumpage	2080	HP		$3,369,100
New Well Pumps	947	HP	$2,025	$1,917,600
Power Tap In	1	LS		$793,000

TOTAL PIPING/PUMPING				$14,238,900
				============

Table E-10 (Continued)
COST ESTIMATES FOR OU 5TUV - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Treatment/Process				
VOC Removal	1	LS	$1,064,000	$1,064,000
Nitrate Removal	1	LS	$1,041,100	$1,041,100

TOTAL TREATMENT				$2,105,100
				===========
CONSTRUCTION SUBTOTAL				$18,583,000
Bid Contingencies @ 15%				$2,787,500
Scope Contingencies @ 25%				$4,645,800

CONSTRUCTION TOTAL				$26,016,300
Services During Construction @ 10%				$2,601,600
Land Acquisition	1	LS		$300,000

TOTAL IMPLEMENTATION COST				$28,917,900
Engineering, Legal & Admin Cost @ 22%				$6,361,900

TOTAL CAPITAL COST				$35,280,000
FEASIBILITY STUDY:				
FS Study - Large	1	LS	$724,000	$724,000

TOTAL RI/FS COST:				$724,000
				===========
TOTAL OU COST:				$36,004,000
ANNUAL OPERATIONS & MAINTENANCE COST				
New Wells	1	LS	$90,500	$90,500
Pipeline & Pump	1	LS	$332,500	$332,500
Treatment Facilities	1	LS	$562,200	$562,200

TOTAL ANNUAL O & M COST:				$985,000
				===========

Notes:

Unit Codes	Abbreviations
LS = lump sum	Mob = mobilization
MO = month	" = inches
EA = each	Xfer= transfer
LF = linear feet	FS = feasibility study
HP = horsepower	RI = remedial investigation
	CL = class
	DI = ductile iron

Table E-11
COST ESTIMATES FOR OU 5CDGFIJ - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$1,516,500
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000

TOTAL GENERAL				$1,887,700
				===========
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	13800	LF	$49.00	$676,200
18" Dia CL52 DI Pipe	25600	LF	$65.20	$1,669,100
24" Dia CCP Pipe	27400	LF	$93.20	$2,553,700
River Crossings				
For 18" Dia CL52 DI Pipe	4	EA	$46,600	$186,400
Highway Crossings				
Bore & Jack for 12" Dia DI Pipe	1	EA	$158,600	$158,600
Shutoff Valves				
For 12" Pipe	9	EA	$3,000	$27,600
For 18" Pipe	17	EA	$6,600	$112,600
For 24" Pipe	18	EA	$10,100	$184,500
Pressure Relief/Blowoff Valve Sta.	1	LS		$245,000
Easement Cost	1	LS		$383,400
Pumping				
Surface Transfer Pumps	7168	HP		$9,676,900
Power Tap In	1	LS		$1,451,500

TOTAL PIPING/PUMPING				$17,325,500
				===========

Table E-11 (Continued)
COST ESTIMATES FOR OU 5CDGFIJ - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Plant Nos. 1 & 2 (12,000gpm/ea.)				
VOC Removal	1	LS	$2,394,300	$2,394,300
Nitrate Removal	1	LS	$2,334,300	$2,334,300
Plant No. 3 (15,000gpm)				
VOC Removal	1	LS	$1,384,900	$1,384,900
Nitrate Removal	1	LS	$1,465,200	$1,465,200
TOTAL TREATMENT				$7,578,700
CONSTRUCTION SUBTOTAL				$26,791,900
Bid Contingencies @ 15%				$4,018,800
Scope Contingencies @ 25%				$6,698,000
CONSTRUCTION TOTAL				$37,508,700
Services During Construction @ 10%				$3,750,900
Land Acquisition	3	EA	$300,000	$900,000
TOTAL IMPLEMENTATION COST				$42,159,600
Engineering, Legal & Admin Cost @ 22%				$9,275,100
TOTAL CAPITAL COST				$51,435,000
REMEDIAL INVESTIGATION:				
Install & Sample MW 5-1 (1500')	2	EA	$389,200	$778,400
TOTAL REMEDIAL INVESTIGATION:				$778,400
FEASIBILITY STUDY:				
FS Study - Large	1	LS	$724,000	$724,000
TOTAL RI/FS COST:				$1,502,400
TOTAL OU COST:				$52,937,400
ANNUAL OPERATIONS & MAINTENANCE COST				
Pipeline & Pump	1	LS	$668,700	$668,700
Treatment Facilities	1	LS	$2,922,300	$2,922,300
TOTAL ANNUAL O & M COST:				$3,591,000

Note: See Table E-8 for explanation of units and abbreviations.

Table E-12
COST ESTIMATES FOR OU 5CDGFIJ - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$2,668,600
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000
TOTAL GENERAL				$3,039,800
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	68600	LF	$49.00	$3,361,400
18" Dia CL52 DI Pipe	53400	LF	$65.20	$3,481,700
24" Dia CCP Pipe	47500	LF	$93.20	$4,427,000
River Crossings				
For 12" Dia CL52 DI Pipe	2	EA	$36,000	$72,000
For 18" Dia CL52 DI Pipe	2	EA	$46,600	$93,200
For 24" Dia CCP Pipe	2	EA	$60,100	$120,200
Highway Crossings				
Bore & Jack for 12" Dia DI Pipe	2	EA	$158,600	$317,200
Bore & Jack for 18" Dia DI Pipe	2	EA	$158,600	$317,200
Bore & Jack for 24" Dia CCP Pipe	2	EA	$171,600	$343,200
Shutoff Valves				
For 12" Pipe	46	EA	$3,000	$137,200
For 18" Pipe	36	EA	$6,600	$235,000
For 24" Pipe	32	EA	$10,100	$319,800
Pressure Relief/Blowoff Valve Sta.	1	LS		$563,500
Easement Cost	1	LS		$972,800
Pumping				
Surface Transfer Pumps	14020	HP	$0	$18,926,200
Power Tap In	1	LS		$2,838,900
TOTAL PIPING/PUMPING				$36,526,500

Table E-12 (Continued)
COST ESTIMATES FOR OU 5CDGFIJ - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Plant Nos. 1 & 2 (12,000 gpm/ea.)				
VOC Removal	1	LS	$2,394,300	$2,394,300
Nitrate Removal	1	LS	$2,334,300	$2,334,300
Plant No. 3 (15,000gpm)				
VOC Removal	1	LS	$1,384,900	$1,384,900
Nitrate Removal	1	LS	$1,465,200	$1,465,200
TOTAL TREATMENT				$7,578,700
CONSTRUCTION SUBTOTAL				$47,145,000
Bid Contingencies @ 15%				$7,071,800
Scope Contingencies @ 25%				$11,786,300
CONSTRUCTION TOTAL				$66,003,100
Services During Construction @ 10%				$6,600,300
Land Acquisition	3	EA	$300,000	$900,000
TOTAL IMPLEMENTATION COST				$73,503,400
Engineering, Legal & Admin Cost @ 22%				$16,170,700
TOTAL CAPITAL COST				$89,674,000
REMEDIAL INVESTIGATION:				
Install & Sample MW 5-1 (1500')	2	EA	$389,200	$778,400
TOTAL REMEDIAL INVESTIGATION:				$778,400
FEASIBILITY STUDY:				
FS Study - Large	1	LS	$724,000	$724,000
TOTAL RI/FS COST:				$1,502,400
TOTAL OU COST:				$91,176,400
ANNUAL OPERATIONS & MAINTENANCE COST				
Pipeline & Pump	1	LS	$1,360,600	$1,360,600
Treatment Facilities	1	LS	$2,922,300	$2,922,300
TOTAL ANNUAL O & M COST:				$4,283,000

Note: See Table E-8 for explanation of units and abbreviations.

E.3.7 OPERABLE UNIT 5W

The total Capital Cost for this OU, assuming the first distribution alternative, is estimated at $18,914,000 (Table E-13). Although OU 5W includes four new extraction wells, a treatment facility utilizing air stripping with vapor-phase carbon off-gas treatment for VOC removal, with ion-exchange units for nitrate removal, the relatively small number of wells at which production is curtailed limits its estimated cost. With remedial investigation and feasibility costs, the estimated cost of implementation is $19,456,400. The costs associated with the second piping scenario are estimated at $21,763,000 Capital, and a total implementation cost of $22,305,400 (Table E-14). O&M costs are estimated at $765,000 and $813,000, respectively for the two alternatives.

E.3.8 OPERABLE UNIT 6AB

The estimated costs of implementing OU 6AB are presented in Tables E-15 and E-16. The costs for this operable unit, which consider one treatment facility utilizing air stripping with vapor-phase carbon off-gas treatment for VOC removal with ion-exchange units for nitrate removal and distribution piping and associated pumps, are even more limited than those estimated for OU 5W because of the use of existing wells. Assuming the first piping alternative, the total Capital Cost is estimated at $9,877,000, and the total cost of implementation is estimated at $10,479,400. Using the second distribution scenario increases the estimated Capital Cost to $11,779,000, and the total cost of implementation to $12,381,400. O&M estimates range from an annual $296,000 for the first alternative, and $319,000 annually for the second distribution alternative.

Table E-13
COST ESTIMATES FOR OU 5W - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$558,800
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000

TOTAL GENERAL				$930,000
				===========
EXTRACTION WELLS:				
New Well Installations	4	EA	$259,000	$1,036,000
Electrical (Allowance)	1	LS		$51,800

TOTAL WELLS				$1,087,800
				===========
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	2400	LF	$49.00	$117,600
18" Dia CL52 DI Pipe	13900	LF	$65.20	$906,300
24" Dia CCP Pipe	6500	LF	$93.20	$605,800
Shutoff Valves				
For 12" Pipe	2	EA	$3,000	$4,800
For 18" Pipe	9	EA	$6,600	$61,200
For 24" Pipe	4	EA	$10,100	$43,800
Pressure Relief/Blowoff Valve Sta.	1	LS		$81,500
Easement Cost	1	LS		$130,900
Pumping				
Surface Transfer Pumpage	1427	HP		$2,208,900
New Well Pumps	540	HP	$2,025	$1,093,300
Power Tap In	1	LS		$495,300

TOTAL PIPING/PUMPING				$5,749,400
				===========

Table E-13 (Continued)
COST ESTIMATES FOR OU 5W - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Treatment/Process				
VOC Removal	1	LS	$1,064,000	$1,064,000
Nitrate Removal	1	LS	$1,041,100	$1,041,100
TOTAL TREATMENT				$2,105,100
CONSTRUCTION SUBTOTAL				$9,872,300
Bid Contingencies @ 15%				$1,480,800
Scope Contingencies @ 25%				$2,468,100
CONSTRUCTION TOTAL				$13,821,200
Services During Construction @ 10%				$1,382,100
Land Acquisition	1	LS		$300,000
TOTAL IMPLEMENTATION COST				$15,503,300
Engineering, Legal & Admin Cost @ 22%				$3,410,700
TOTAL CAPITAL COST				$18,914,000
FEASIBILITY STUDY:				
Small FS Study	1	LS	$542,400	$542,400
TOTAL RI/FS COST:				$542,400
TOTAL OU COST:				$19,456,400
ANNUAL OPERATIONS & MAINTENANCE COST				
New Wells	1	LS	$49,600	$49,600
Pipeline & Pump	1	LS	$153,100	$153,100
Treatment Facilities	1	LS	$562,200	$562,200
TOTAL ANNUAL O & M COST:				$765,000

Notes:

Unit Codes	Abbreviations
LS = lump sum	Mob = mobilization
MO = month	" = inches
EA = each	Xfer= transfer
LF = linear feet	FS = feasibility study
HP = horsepower	RI = remedial investigation
	CL = class
	DI = ductile iron

Table E-14
COST ESTIMATES FOR OU 5W - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$644,600
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000
TOTAL GENERAL				$1,015,800
EXTRACTION WELLS:				
New Well Installations	4	EA	$259,000	$1,036,000
Electrical (Allowance)	1	LS		$51,800
TOTAL WELLS				$1,087,800
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	10500	LF	$49.00	$514,500
18" Dia CL52 DI Pipe	11100	LF	$65.20	$723,700
24" Dia CCP Pipe	13200	LF	$93.20	$1,230,200
River Crossings				
For 18" Dia CL52 DI Pipe	1	EA	$46,600	$46,600
Highway Crossings				
Bore & Jack for 18" Dia DI Pipe	2	EA	$158,600	$317,200
Shutoff Valves				
For 12" Pipe	7	EA	$3,000	$21,000
For 18" Pipe	7	EA	$6,600	$48,800
For 24" Pipe	9	EA	$10,100	$88,900
Pressure Relief/Blowoff Valve Sta.	1	LS		$123,400
Easement Cost	1	LS		$199,700
Pumping				
Surface Transfer Pumpage	1660	HP		$2,268,300
New Well Pumps	540	HP	$2,025	$1,093,300
Power Tap In	1	LS		$504,200
TOTAL PIPING/PUMPING				$7,179,800

Table E-14 (Continued)
COST ESTIMATES FOR OU 5W - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
TREATMENT				
Treatment/Process				
VOC Removal	1	LS	$1,064,000	$1,064,000
Nitrate Removal	1	LS	$1,041,100	$1,041,100
TOTAL TREATMENT				$2,105,100
CONSTRUCTION SUBTOTAL				$11,388,500
Bid Contingencies @ 15%				$1,708,300
Scope Contingencies @ 25%				$2,847,100
CONSTRUCTION TOTAL				$15,943,900
Services During Construction @ 10%				$1,594,400
Land Acquisition	1	LS		$300,000
TOTAL IMPLEMENTATION COST				$17,838,300
Engineering, Legal & Admin Cost @ 22%				$3,924,400
TOTAL CAPITAL COST				$21,763,000
FEASIBILITY STUDY:				
Small FS Study	1	LS	$542,400	$542,400
TOTAL RI/FS COST:				$542,400
TOTAL OU COST:				$22,305,400
ANNUAL OPERATIONS & MAINTENANCE COST				
New Wells	1	LS	$49,600	$49,600
Pipeline & Pump	1	LS	$200,700	$200,700
Treatment Facilities	1	LS	$562,200	$562,200
TOTAL ANNUAL O & M COST:				$813,000

Notes:

Unit Codes	Abbreviations
LS = lump sum	Mob = mobilization
MO = month	" = inches
EA = each	Xfer= transfer
LF = linear feet	FS = feasibility study
HP = horsepower	RI = remedial investigation
	CL = class
	DI = ductile iron

Table E-15
COST ESTIMATES FOR OU 6AB - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$286,500
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000

TOTAL GENERAL				$657,700
				============
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	2250	LF	$49.00	$110,300
18" Dia CL52 DI Pipe	13400	LF	$65.20	$873,700
24" Dia CCP Pipe	7000	LF	$93.20	$652,400
Highway Crossings				
Bore & Jack for 18" Dia DI Pipe	1	EA	$158,600	$158,600
Shutoff Valves				
For 12" Pipe	2	EA	$3,000	$4,500
For 18" Pipe	9	EA	$6,600	$59,000
For 24" Pipe	5	EA	$10,100	$47,100
Pressure Relief/Blowoff Valve Sta.	1	LS		$81,800
Easement Cost	1	LS		$130,000
Pumping				
Surface Transfer Pumpage	462	HP		$1,332,000
Power Tap In	1	LS		$199,800

TOTAL PIPING/PUMPING				$3,649,200
				============
TREATMENT				
Treatment/Process				
VOC Removal	1	LS	$253,600	$253,600
Nitrate Removal	1	LS	$501,500	$501,500

TOTAL TREATMENT				$755,100
				============

Table E-15 (Continued)
COST ESTIMATES FOR OU 6AB - FIRST DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
CONSTRUCTION SUBTOTAL				$5,062,000
Bid Contingencies @ 15%				$759,300
Scope Contingencies @ 25%				$1,265,500
CONSTRUCTION TOTAL				$7,086,800
Services During Construction @ 10%				$708,700
Land Acquisition	1	LS		$300,000
TOTAL IMPLEMENTATION COST				$8,095,500
Engineering, Legal & Admin Cost @ 22%				$1,781,000
TOTAL CAPITAL COST				$9,877,000
REMEDIAL INVESTIGATION:				
Well Sampling (5 wells)	1	LS		$60,000
TOTAL REMEDIAL INVESTIGATION:				$60,000
FEASIBILITY STUDY:				
Small FS Study	1	LS	$542,400	$542,400
TOTAL RI/FS COST:				$602,400
TOTAL OU COST:				$10,479,400
ANNUAL OPERATIONS & MAINTENANCE COST				
Pipeline & Pump	1	LS	$91,600	$91,600
Treatment Facilities	1	LS	$204,100	$204,100
TOTAL ANNUAL O & M COST:				$296,000

Notes:

Unit Codes	Abbreviations
LS = lump sum	Mob = mobilization
MO = month	" = inches
EA = each	Xfer= transfer
LF = linear feet	FS = feasibility study
HP = horsepower	RI = remedial investigation
	CL = class
	DI = ductile iron

Table E-16
COST ESTIMATES FOR OU 6AB - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
GENERAL:				
Mob, & General Reqm'ts @ 6%	1	LS		$343,800
Construction Admin. Trailer	24	MO	$300	$7,200
Security Service	24	MO	$2,500	$60,000
Community Relations	24	MO	$5,000	$120,000
Health & Safety Program				
Physicals (2/Worker)	60	EA	$800	$48,000
Training	30	EA	$1,200	$36,000
Permits	1	LS		$100,000
TOTAL GENERAL				$715,000
PIPING/PUMPING:				
Pipe Thru Developed Land				
12" Dia CL52 DI Pipe	15300	LF	$49.00	$749,700
18" Dia CL52 DI Pipe	3400	LF	$65.20	$221,700
24" Dia CCP Pipe	16400	LF	$93.20	$1,528,500
River Crossings				
For 24" Dia CCP Pipe	2	EA	$60,100	$120,200
Shutoff Valves				
For 12" Pipe	10	EA	$3,000	$30,600
For 18" Pipe	2	EA	$6,600	$15,000
For 24" Pipe	11	EA	$10,100	$110,400
Pressure Relief/Blowoff Valve Sta.	1	LS		$125,000
Easement Cost	1	LS		$201,400
Pumping				
Surface Transfer Pumpage	552	HP		$1,305,900
Power Tap In	1	LS		$195,900
TOTAL PIPING/PUMPING				$4,604,300
TREATMENT				
Treatment/Process				
VOC Removal	1	LS	$253,600	$253,600
Nitrate Removal	1	LS	$501,500	$501,500
TOTAL TREATMENT				$755,100

Table E-16 (Continued)
COST ESTIMATES FOR OU 6AB - SECOND DISTRIBUTION ALTERNATIVE

DESCRIPTION	QUAN	UNIT	$/UNIT	TOTAL
CONSTRUCTION SUBTOTAL				$6,074,400
Bid Contingencies @ 15%				$911,200
Scope Contingencies @ 25%				$1,518,600

CONSTRUCTION TOTAL				$8,504,200
Services During Construction @ 10%				$850,400
Land Acquisition	1	LS		$300,000

TOTAL IMPLEMENTATION COST				$9,654,600
Engineering, Legal & Admin Cost @ 22%				$2,124,000

TOTAL CAPITAL COST				$11,779,000
REMEDIAL INVESTIGATION:				
Well Sampling (5 wells)	1	LS		$60,000

TOTAL REMEDIAL INVESTIGATION:				$60,000
FEASIBILITY STUDY:				
Small FS Study	1	LS	$542,400	$542,400

TOTAL RI/FS COST:				$602,400
				===========
TOTAL OU COST:				$12,381,400
ANNUAL OPERATIONS & MAINTENANCE COST				
Pipeline & Pump	1	LS	$115,200	$115,200
Treatment Facilities	1	LS	$204,100	$204,100

TOTAL ANNUAL O & M COST:				$319,000
				===========

Notes:

Unit Codes	Abbreviations
LS = lump sum	Mob = mobilization
MO = month	" = inches
EA = each	Xfer= transfer
LF = linear feet	FS = feasibility study
HP = horsepower	RI = remedial investigation
	CL = class
	DI = ductile iron

E.4.0 REFERENCES

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Appendix F
ALTERNATE STAGE III ACTIVITIES

APPENDIX F

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TABLES

FIGURES

Appendix F
ALTERNATE STAGE III ACTIVITIES

This appendix summarizes an alternate set of recommended actions for Stage III. As explained in Section 7.0, the formulation of future stages presupposes what the results of future investigations in the basin will be. These alternate Stage III activities illustrate the potential impact of changes in the current interpretation of basinwide conditions. Because this appendix is basically a potential variation of Section 7.0, the discussion has been compressed and only includes areas in which the two scenarios differ.

F.1.0 BASELINE CONDITIONS

Conditions of groundwater flow and extent of contamination at the outset of Stage III are estimated in a qualitative fashion as a function of (1) time, (2) the effects of remedial actions already implemented in Stages I and II, and (3) assumptions regarding the results of remedial investigations. Because the time factor and the effects of remedial actions already implemented are identical to that presented in Section 7.0, the following discussion pertains only to the results of remedial investigations.

F.1.1 ASSUMED RESULTS OF REMEDIAL INVESTIGATIONS

Several assumptions are described below regarding the general nature of the results of remedial investigations conducted prior to Stage III. These assumptions are presented as an alternative to those presented in Section 7.0.

In Area 2, well logging and depth-specific sampling of three existing wells and two deep monitoring wells are assumed to provide data that suggest that contamination is concentrated in fairly well-defined horizons that are limited to the shallow portions of the aquifer, and completely absent in the deeper screened intervals. These data support the installation of two additional monitoring wells to the south to better define the downgradient boundary of contamination above maximum contaminant levels (MCLs). Information from these wells may be used to design an operable unit (OU) at the downgradient boundary to contain contamination to its present extent and remove it as it migrates southward.

Area 3 investigations in Stage II are assumed to indicate contamination is fairly uniformly distributed with depth at the northern monitoring well (MW 3-3), with no indication of decreasing concentrations with depth. Two additional monitoring wells will be installed to further investigate the deepest portion of the aquifer in Area 3.

The results of logging and sampling of two new monitoring wells in the northern portion of Area 4 are assumed to reveal only very low levels of contamination and suggest that contamination between Whittier Narrows and Areas 5 and 6 may not be continuous. This may indicate that an action to control contaminant migration into the northeastern corner of Area 4 is feasible.

Depth-specific sampling of eight existing wells and three deep monitoring wells in Area 5 is assumed to indicate that contamination occurs at high levels (typically greater than 100 ppb) throughout the depth of the aquifer. In addition, the results of spinner logging over time suggest that the contamination at depth is migrating at velocities that are substantially greater than those affecting contamination in shallower portions of the aquifer. Thus, although treatment facilities and modifications to the 5CDGFIJ wells are currently in the design phase, it is apparent, in light of the data gathered from the deep monitoring wells, that additional remedial actions in the area will not be cost-effective. Instead, the deep contamination in Area 5 will be dealt with in subsequent stages with remedial actions further downgradient toward Whittier Narrows.

Tracer tests in the San Jose Creek and underlying gravel subdrain system are assumed to substantiate the potential for rapid migration of high concentrations of contaminants from the Puente Valley toward Area 4. In addition, the presence of significant contamination in surface water, similar to that found in groundwater nearby, may suggest a strong connectivity between the two systems. VOC concentrations in the creek are assumed to be high enough to be considered a potential threat to humans in the vicinity. These data may support the immediate need for remediation of the creek itself to prevent exposure of the public to the toxic levels of solvents in the surface water. Additional data from two new monitoring wells in the far western portion of Area 6 indicate that the downgradient boundary of contamination from the Puente Valley is well defined and located very close to the Area 4 boundary. Source investigations have identified the sources of recent contamination with whom negotiations are underway for the financing of OU 5W.

F.2.0 SUMMARY OF ACTIONS

Remediation efforts to be undertaken in Stage III focus on actions in Areas 2, 4, and 6. Remedial investigations will be performed to support the three Stage III remedial actions, and to support potential Stage IV actions by further exploring conditions in the deepest portion of the aquifer in Area 3. Stage III actions are summarized in Table F-1, and Figure F-1.

The emphasis of the Alternative Stage III actions is on (1) the initiation of remedial efforts to control migration within Area 2 and into Area 4, and (2) remove contaminated and imminently hazardous materials from the San Jose Creek. The nature of these actions is largely dependent on the results of

Table F-1
SUMMARY OF ALTERNATE STAGE III ACTIONS

RI Area	Type of Action	Rationale	Activities
Area 2	Remedial Investigation	Better define the downgradient extent of contamination to support remedial action in Stages III, and potentially, IV. Monitoring wells will be constructed as part of Feasibility Study for Operable Unit 2J.	Installation and depth-specific sampling of two new monitoring wells (MW 2-4, MW 2-5).
	Remedial Action	Provide a local supply of potable water, and extract contamination at its present downgradient boundary to manage further migration southward. An additional monitoring well will provide long-term performance monitoring, and help support potential remedial actions in Stage IV.	Operable Unit 2J, including installation and depth-specific sampling of one new monitoring well (MW 2-2).
Area 3	Remedial Investigation	Better define the extent of contamination to support remedial action in Stage IV, and support basinwide investigations.	Installation and depth-specific sampling of two new monitoring wells (MW 3-1, MW 3-2).
Area 4	Remedial Action	Prevent imminent migration of contamination from Areas 5 and 6 into Area 4.	Operable Unit 4K
Area 6	Remedial Action	Prevent the imminent threat of exposure of the public to high-level contamination in San Jose Creek.	Operable Unit SJC

Continue

investigations performed in Stage II. Migration control actions are considered viable at this stage primarily because of the results of Stage II investigations, which may indicate that the extent of contamination in Areas 2, 5, and 6 is relatively limited. May suggest an opportunity to contain migration before individual zones of contamination coalesce further.

F.3.0 OPERABLE UNIT 2J

As discussed above, OU 2J will be used to prevent high concentrations of contamination confined to the upper portion of the aquifer in the central and northern parts of Area 2 from migrating southward. Contamination in the southern portion of Area 2 appears, on the basis of assumed data from source investigations in the area, very shallow and largely treatable by actions at source facilities. Implementation of OU 2J is considered the best course of action in this case because it should prevent contamination in this southern area from worsening and requiring additional action (as described in Section 8.0) at a later stage. Operable Unit 2J represents an alternative to OU 2BCFHK (Section 7.0), which would probably more effectively remove contamination from throughout the large contaminated zone in Area 2, but provide a lesser degree of migration control.

The results of numerical simulations (Appendix C) indicate that implementation of either OU 2J or OU 2BCFHK could allow contamination in the south to increase more quickly than it would otherwise. In the case of OU 2BCFHK, described as a Stage III action in Section 7.0, this is recognized and compensated for in Stage IV. In this alternative scenario, it is envisioned that further definition of the vertical and lateral extent of contamination in the central and northern portions of Area 2 could support the design and installation of OU 2J wells that will effectively capture all southward migrating contamination. In addition, much of the increase in contamination in the southern part of Area 2 is the result of removing wells in the area from operation to prevent production of a large volume of excess water from the OU 2J wells. A feasibility study of OU 2J will resolve whether this is the best course of action; other alternatives could include removing wells in other areas, or disposing excess water to spreading grounds, rivers, or to satisfy an increase in demand. Furthermore, the effects of source-control actions precipitated by source investigations already underway in the southern part of Area 2 may already have alleviated contamination problems in that area.

Remedial investigations in Stage II included depth-specific sampling of three wells and two monitoring wells, which would support design of new extraction wells to some degree. Additional investigation, described above and summarized below, might include the installation and sampling of two additional monitoring wells (MW 2-4 and MW 2-5) to better define the location of the downgradient boundary of contamination in Area 2. These would be located